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EFFECTS OF VARYING THE ENVIRONMENT ON THE BEHAVIOUR AND PERFORMANCE OF DAIRY CATTLE

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SUMMARY

Selection of farm animals has been based upon productivity and behavioural traits. Attempts to measure the environment of the cow utilize score card, multiple regression and production function appraisals. Feeding, milking practices and high milk production per cow emerge as the most important variables. Management ability and success of 30 California commercial dairymen with large-scale herds was measured illustrating a consistent year-to-year pattern.

Social structures exist in all dairy herds. In adult animals they are essentially linear. Psychological disturbances, such as placing a new member into the herd, isolation of a cow from herdmates, stressful stimuli such as predators and climatic shifts, affect milk production and composition. Attempts to measure temperament are difficult and generally involve the milk ejection reflex. Four types of nervous activities in cows illustrate their wide differences in milk production.

Estimates of heritability for temperament and dominance were high (0.5 and 0.4 on a basis of 1.0, respectively). The relationship between temperament and dominance scores with milk production appears unresolved.

The behaviour of cows entering the milking shed illustrates that cows are consistent and these patterns are linked with previous training to one side of the parlour or the other. Higher producers enter the milking area earlier than lower yielding ones during early lactation.

Milk production as well as social and maternal behaviour was modified considerably by early calfhood feeding and rearing experiences.

BEHAVIOURAL DIFFERENCES in animals and man as related to various environmental factors have attracted the attention of farmers and biologists. The total environment of man, with his domesticated and wild animals, is constantly changing. One of the greatest dangers in trying to understand an animal is the tendency to humanize (Hedi-

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ger, 1968). There is only one species of man — *homo sapiens* — but about a million different species of living creatures with a few hundred more being discovered every year. It is understandable that those animals with which man comes into closest daily contact at home, on the farm, should be chosen as a starting point for animal psychology; such animals as dogs, cats, horses, cattle, sheep, goats, rabbits, etc. These animals are not pure natural products. After centuries of breeding by man, farm animals have undergone definite changes in the course of domestication. The artificial selection was based not only upon productivity but also on behavioural characteristics. In producing milk, meat, eggs and wool, the conditioned reflexes beneficial to man have been developed in animals. The unconditioned reflexes have also been changed during the process, *i.e.*, high-milk-producing dairy cows and productive hens are known to lose some degree of maternal instinct (Baryschnikov and Kokorina, 1964).

MEASURING THE ENVIRONMENT AND MAN

Attempts to measure the environment have revealed the importance of the "micro-environment", as well as management, herdsmanship and cowmanship (Albright and Alliston, 1971). Such techniques as score card subjective appraisal (Bayley and Heizer, 1952; Starkey *et al.*, 1958) have been used to measure up to 150 variables (Corley *et al.*, 1964) extended to 100 Wisconsin dairy farms (Hansen *et al.*, 1968). Practices related to milking and feeding accounted for the greatest variation in milk production among herds.

A multiple regression analysis was used for 340 Michigan dairy farms to study the relationship between 38 management factors and net income (Sneicher and Lasiter, 1965). Fourteen factors were significant ($P < 0.05$) in explaining variations in net income. Livestock income per \$100 feed expense and crop value per tillable acre accounted for 87% of the variation in net income attributed to all livestock and cropping factors. In a five-year study (Albright *et al.*, 1964) of commercial dairy herds in California averaging 290 cows, a production function analysis revealed that milk production per cow emerges as the most important variable ($P < 0.01$) influencing economic performance in all five years. Conformance to the feeding standard had a significant ($P < 0.05$) influence on economic performance in two of the five years analyzed. The prices paid for hay, concentrates and cows, percent-

age of dry cows, and culling percentage showed no significant influence.

There is strong evidence that dairymen who excel, ranked according to (1) deviation of value of production from regression in inputs or (2) by percentage return on capital investment, are consistently superior from year to year. A similar consistency is evident for those dairymen who are average and inferior. To test the hypothesis that annual ratings of dairymen are random, against the hypothesis that there is a consistent year-to-year pattern in the rankings, the coefficient of concordance was used (Kendall, 1943). The *W*-value of 0.64 was statistically significant ($P < 0.01$). Since there is a consistent year-to-year pattern, an average ranking for superior, average and inferior managers from 30 dairymen for the five-year period was calculated and is shown in Table 1.

TABLE 1: RANKING OF MANAGEMENT ABILITY OF 30 OF 30 DAIRYMEN WITH 30 LARGE COMMERCIAL DAIRY HERDS OVER A 5-YEAR PERIOD

<i>Dairyman</i>	<i>Rankings by Year</i>					<i>Overall Av.</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	
Superior	6	4	7	5	1	1
Average	22	21	20	10	13	15
Inferior	26	26	26	30	29	30

Decision-making ability is measured in industry with selected case studies using in- and out-basket techniques and monitored by closed circuit television. Such tasks are used to study the individual and his ability to cope with situations within a time limit. It would be interesting to study dairy farmers and their families in such a behavioural laboratory. In addition to decision-making by individuals or groups, behaviour and temperament are measured.

SOCIAL DOMINANCE AND TEMPERAMENT

Some attempts have been made to measure the interaction of the temperament of humans and cows. Most studies have been with the milking act. During Russian studies of the milk ejection reflex when the milkmaid inserted the catheter into the cow the milk flowed immediately after it was inserted. When the catheter was not inserted by the regular milker but by the laboratory

assistant the first portion of milk was considerably less than usual. After the cows had been milked for seven days by the laboratory assistant, the cows' reaction to the insertion of the catheter by the milkmaid and the laboratory assistant produced the same conditional reflex (Baryshnikov and Kokorina, 1959). Any disturbance of the consecutive stereotypic complex of conditions at milking time leads to inhibition of the conditioned reflex of milk let-down. Such environmental changes in New Zealand as isolating cows from the herd, being chased by a dog, and thunder storms, all are stressful to the cow and cause increased leucocytes in the milk (Whittlestone *et al.*, 1970).

A social structure is exhibited in all herds. Social dominance is the phenomenon observed in groups when certain individuals initiate (and win) encounters. In animals this type of behaviour was first reported by Schjelderup-Ebbe (1913) in poultry and most studies of social dominance have been done with poultry (Guhl, 1953; Wood-Gush, 1955). They indicated that in small flocks social orders tended to be linear where the top bird pecks all, the next bird all but the top one; however, complete linearity is rare in large flocks.

Schein (1954) in a herd of 87 Holstein-Friesian and Ayrshire cows on pasture found that there was a straight line social order. The order was clearly defined with no triangular or higher order relationships. Schein made his observations by driving a truck into the middle of the field and standing on it. What effect this had on behaviour and/or milk production remains undetermined. Social dominance rank was highly significantly correlated with age and weight. Hook *et al.* (1965) found under confinement competitive feeding conditions that the simultaneous removal of a high-ranking Holstein-Friesian heifer and addition of a new one to a group of six would often cause a complete reversion of the social order. Dominance and weight were significant ($P < 0.05$) in three out of nine social situations, but two subjects, both of which achieved a position of dominance, were among the youngest and smallest animals studied. In the five- to eight-month-old heifers, those which had dominating tendencies had a three-fold greater increase in total conflicts with other animals than the random group of 12 heifers.

Schein *et al.* (1955) did report that the psychological disturbance of placing a new member into the herd structure led to a 5% average decline in milk yield.

The Russians (Baryshnikov and Kokorina, 1959, 1964; Kokorina, 1961; Kudryavtzev, 1962) have continued Pav-

lov's typological classification of dogs to cows, and report wide differences in milk production in cows. Their classifications of types of nervous activity and various indices of milk production are found in Table 2. It would be interesting to know at what age the classifications for nervous types were made. These investigations claim that the cows of the strong, balanced, versatile (unrestrained) type of higher nervous activity had the highest milk and milkfat yields ($P < 0.01$); had higher persistency of lactation with smaller daily variations in yield and they reached a higher milk yield early in their productive life. The cows of the weak type were poorest in all indices and the other two types were intermediate.

TABLE 2: MILK PRODUCTION IN COWS WITH DIFFERENT TYPES OF HIGHER NERVOUS ACTIVITY

<i>Type of Higher Nervous Activity</i>	<i>No. of Cows</i>	<i>Yield (litre)</i>	<i>B'fat Yield (kg)</i>
Strong balanced, versatile (unrestrained)	15	6130 ± 90	225 ± 4.4
Strong, unbalanced (movable)	21	5429 ± 91	196 ± 3.4
Strong, balanced, inert (calm)	7	4987 ± 92	188 ± 7.2
Weak	7	4619 ± 131	174 ± 4.1

After Kokorina, 1961; and Kudryavtzev, 1962.

Kudryavtzev (1962) has ranked the senses in cows as follows: olfaction, cutaneous, auditory, vision and taste. Taste sensitivity and receptivity changes somewhat with different feeds. According to the animal trainers, Breland and Breland (1966), cows move at their own pace regardless of how hungry they are, and the only way to change a cow's disposition to hurry is to frighten or punish it.

Studies in social dominance and temperament in dairy cattle has been largely limited to single herds which, in turn, are generally small. Dickson *et al.* (1970) studied social dominance in 1,017 cows in 27 herds. Dominance value correlation with milking temperament as well as yearly milk yield were both negative. Estimates of heritability for temperament score were approximately 0.5 (on a basis of 1.0) regardless of method of calculation. Simple correlation of milking temperament score with yearly lactation yield was close to zero. These high estimates would indicate that the additive genetic variance for temperament

score in dairy cows is large enough for selection to be effective without adversely affecting milk yield. Many artificial breeding organizations in the United States are routinely giving temperament ratings on daughters of their bulls. For example, one bull stud rates their bulls into one of three temperament categories on their ability to sire daughters of similar disposition, e.g., + + +, + +, +.

Beilharz *et al.* (1966) computed social dominance heritability values to be 0.4 for Holstein-Friesian and Guernseys and found, like Dickson *et al.* (1970), that they have little effect on milk production. When dominance values were calculated separately by three pairs of observers on each of three days in one week, repeatability of such ratings was high, ranging from 0.7 to 0.8.

SOCIAL ORDERS

Dickson *et al.* (1965), while studying social dominance and other social relationships in dairy herds, observed that when cows were given adequate opportunity for social interaction, the dominance hierarchy is so stable that a single day's observation can determine the order. They suggest that there are three social orders which develop among cows — a milking order, a leadership-followership pattern and a dominance order. Kilgour and Scott (1959) in a herd of 30 Friesian cows found there were consistent orders for movement: (a) Top-dominance cows are seldom in the rear but usually in the middle; (b) Mid-dominance cows tend to be in advance of herd movements; (c) Low-dominance cows are at the rear of herd movements.

Once the social order is established in adult cattle, it tends to be maintained but may be disrupted by illness, dehorning, and removal or addition of animals. Entrance behaviour into the milking shed has been studied by many workers. Ferguson *et al.* (1967) observed the entrance order of 151 Holstein-Friesian, Jersey and Red Danish cows in several groups of 16 to 48 that were maintained in feedlots. Highly significant correlations were found between first-season training and side of the parlour entered and current entrance order. Positive correlations between entrance rank and milk production approached significance. Higher-yielding cows entered the milking area earlier than low-yielding cows during early lactation. Albright *et al.* (1966) observed that there was a consistent milking order into the shed among 40 Jersey cows and

attempted to alter it by training each cow to come in when her number was called. By the end of 15 days of training, 70% of the cows came when their number was called. When the calling was discontinued, however, the cows reverted back to their former entrance order. According to Dietrich *et al.* (1965) body weight and age were not highly correlated with entrance order indicating that young cows of lighter weights were entering the milking parlour at all segments of the entry order. There was a low correlation between milk production and entry into the milking parlour indicating that entrance order could not be accurately used as a criterion in the selection of high-producing cows. Grain feeding at various times before or after milking did not change the order in which the cows entered the milking parlour. Whereas, when cows were milked and fed prior to the regular milking period, there was a significant change in the cows' later entrance order. A decrease in intramammary pressure following milking resulting in less udder stress to the cow and causing her to enter the milking line-up later would explain this. Kostov and Subev (1968) observed two groups of 67 and 26 loose-housed 4- to 11-year-old Bulgarian Sofia Brown cows while entering an 8-stall herringbone parlour. Cows aged 5 to 6 years and cows with higher 300-day yields chose to walk through the parlour first. Cows with lower yields were indifferent as to when they entered the parlour.

EFFECTS OF EARLY FEEDING AND REARING PROCEDURES ON MILK PRODUCTION, SOCIAL AND MATERNAL BEHAVIOUR IN DAIRY CATTLE

The first and only experiment of this type with dairy cattle was the recent work of Donaldson (1967, 1970). An abstract of her work is as follows:

The observed social order is a function of the test situation. A submissive order, *i.e.*, the readiness of an animal to defer to an attacking animal is distinct from the dominance order, *i.e.*, the provoking cow which wins. Both these dominance and submission tendencies of dairy calves could be altered by manipulating early feeding and rearing conditions. Calves that were reared together in groups of three with limited feeding space, regardless of whether they were fed separately, or with other calves, were significantly more dominant than calves reared separately. Calves that were fed together, regardless of their rearing condition, were significantly more submissive than calves

		FEEDING CONDITION	
		Separate	Together
REARING CONDITION	Separate	Group SS fed individually penned individually $n = 9$	Group TS fed in groups of 3 penned individually $n = 9$
	Together	Group ST fed individually penned in groups of 3 $n = 9$	Group TT fed in groups of 3 penned in groups of 3 $n = 9$

FIG. 1: Feeding and rearing conditions of calves.

fed separately. Fed separate-reared separate calves were significantly less dominant and less submissive than other calves while fed together-reared together calves were more dominant and more submissive than calves from other feeding-rearing conditions (Donaldson, 1967).

The 18 Holstein-Friesian heifer calves and 18 Holstein-Friesian-Red Danish crossbred heifer calves were raised from birth until 18 weeks of age under one of four feeding-rearing conditions: fed separate, raised separate (SS); fed separate, raised together (ST); fed together, raised separate (TS); or fed together, raised together (TT) (see Fig. 1). The heifers were maintained thereafter as a group on pasture until their first parturition. When the heifers were 20 months old, agonistic or conflict behaviour was observed daily for six weeks. A Social Index* was computed for each animal and the groups were compared by means of an analysis of variance. The parturition sequence was observed through two calvings during which aspects of maternal behaviour were recorded. The cows were rated on milking parlour behaviour by two full-time milkers. Milk production was recorded daily. Four per cent fat-corrected, 305 day lactation, milk production records were also compared for each group.

*number of encounters initiated/total number of encounters = %.

The results revealed that cows that had been raised together had a higher average Social Index than subjects raised separately ($P < 0.01$). This was in accordance with earlier work (Donaldson, 1967) and was interpreted to mean that early calthood rearing experiences affect adult social behaviour in dairy cattle.

There were differences among the cows in maternal behaviour with their first calf. Raised together cows tended to ignore their young or partially clean them and failed to allow nursing. Raised separately cows tended to fully clean their young and allowed nursing. Raised together cows tended not to protect their young and were quite vocal toward them, while raised separately cows were protective and did not make many vocalizations.

With their second calf, all cows cleaned, nursed and protected their young, but there was a difference in the degree to which these behaviours were performed. Cows that had not given proper care to their first calf were not nearly as efficient at maternal behaviour as those that had taken care of their first calf. It was concluded that early feeding and rearing experiences dramatically affect maternal behaviour in dairy cattle.

Selman *et al.* (1970), in studies on natural suckling in cattle (10 beef cows, 10 dairy cows and 10 dairy heifers) during the first eight hours *post partum* found that teat sucking advances by their calves were rejected at some time by 15 of the 30 dams. These rejections consisted of either moving away from, or kicking at, their calves. However, in 13 of the above 15 dams, rejections were seen only occasionally and usually occurred only when calves pushed vigorously at udders, sucked udder or belly skin, or nibbled the sides of teats. This mild form of rejection inhibited only the weakest calves. When suckling eventually commenced, all 13 dams became very quiet. Two primiparous heifers rejected their calves' advances for 6 to 8 hours. These two animals frequently ran away from their calves. These results and those of Donaldson agree with earlier observations (Hafez, 1964). He stated that "nursing behaviour in older animals is facilitated by the reflexes conditioned during previous lactations, and in primiparous animals is inhibited by the pain and shock of parturition".

There were no statistically significant differences among the groups in milking parlour behaviour (*i.e.*, ease of training to enter the milking parlour initially and one month *post partum*, frequency of kicking, temperament and milking ease).

Milk production was differentially affected by early feeding and rearing experiences. Holstein-Friesians that were fed separately and raised separately yielded an average of as much as 3,520 lb of milk more than Holstein-Friesians fed and raised under any other condition. Crossbreds that were fed together and raised together yielded an average of as much as 2,067 lb of milk more than crossbreds fed and raised under any other condition.

It was concluded that social and maternal behaviour and milk production can be modified by the early feeding and rearing experiences in calves.

CONCLUSIONS

(1) Attempts to measure the cow's environment and management involve score-card evaluation, multiple regression and production function economic analyses, and in-basket, out-basket case study approaches.

High milk production per cow emerges as the most important economic parameter in large commercial California dairy herds. Feeding and milking practices account for the greatest variation in milk production among herds. Dairymen ranked on two separate bases showed consistent year-to-year patterns as to whether they were excellent, mediocre or inferior managers.

(2) Selection has not only been for higher milk production but also involves behavioural characteristics. In the process of domestication, high milk production has been accompanied by a loss of maternal instinct.

(3) Attempts to define and measure temperament are difficult and generally involve the milk ejection reflex. The four types of cows as defined by higher nervous activities also show wide differences in milk production. This work should be repeated and the so-called nervous types assigned prior to lactation.

(4) Estimates of heritability for temperament score in 1,017 cows in 27 dairy herds were approximately 0.5 (on a basis of 1.0). Artificial breeding organizations are routinely making temperament ratings on daughters of their bulls.

Heritability estimate of dominance values were 0.4 and the repeatability of dominance values were high, ranging from 0.7 to 0.8. More work needs to be done in this area.

(5) Social orders include a leadership-followerhip structure, dominance hierarchy, and a milking order. Entrance order into the milking shed was consistent and linked with previous training as well as intramammary pressure. Cows can be trained by a vocal call to respond and enter the milking parlour.

(6) Social and maternal behaviour and milk production can be modified by early calthood feeding and rearing experiences.

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