AN ANALYSIS OF THE EUROPEAN HERDS OF DAIRY CATTLE AT AMBAWELA AND BOPATALAWA*

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INTRODUCTION

THE FIRST large-scale importation of temperate breeds of cattle to Ceylon was made in 1943 when 300 cows and 36 bulls were imported from Australia by the Ceylon Government. This was followed by the importation of a further 595 head from the same country in 1944. These two importations provided the foundation stock for the large herds of European cattle that now populate the Government Cattle Farms at Ambawela (elevation 6,000 ft.) and Bopatalawa (elevation 5,000 ft.) in the central hills of Ceylon. A few occasional importations in more recent times, from Australia and from Great Britain, of a small number of heifers and stud bulls, have also been recorded.

The climatic conditions prevailing at Ambawela and Bopatalawa have been conducive to the well-being of these cattle. The mean monthly temperature at Ambawela, for example, is under 60°F., and because temperature in this part of the country is controlled mainly by the topography of the land, seasonal variations are very slight. But, the daily temperature range is considerable and averages about 20°F. The mean relative humidity is around 75 per cent., but a close relationship is known to exist between daily temperature range and relative humidity, the latter being lowest during the relatively dry months of February and March when the daily temperature range is greatest. Frost may sometimes occur during these months as a result of the ground temperature occasionally dropping below zero during the night. However, the incidence of frost rarely exceeds four or five days for a whole year. Rainfall is fairly evenly distributed although the period December to March often tends to be relatively dry. The total precipitation for the year is about 110 in. at Ambawela and 82 in. at Bopatalawa, and the total number of rainy days in the year averages 235 and 186 respectively.

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The acidity of the soils at these farms (pH 5.3) was a serious obstacle to pasture establishment in the early years, as most pasture grasses cannot grow under these conditions. The natural vegetation consists of tufted, coarse, and wiry grasses, chiefly represented by *Chrysopogon, Ischaemum* and *Themeda* species and a few legumes such as *Smithia blanda, Cassia mimosoides* and *Desmodium* spp. Heavy liming of these *patana* soils had to be undertaken before the introduction of any cultivated species of fodder or pasture. With the introduction of buckwheat (*Fagopyrum sagittatum*) into these farms in 1951, however, the reclamation of *patana* land has proved to be less expensive, as buckwheat tolerates acidity of soils to a large extent. The cultivation of *patana* soils now takes the following sequence : buckwheat—lupins and sunflower—radish—pasture. The major pasture components in the cultivated areas are kikuyu, ryegrass, cocksfoot and clovers.

It would thus be evident that the environmental conditions under which European cattle are reared at Ambawela and Bopatalawa, though differing in a number of respects from those obtaining in temperate countries, are nevertheless not unsuited to them.

DESCRIPTION OF DATA

The herds whose records have been analysed in this work belong to five breeds : Ayrshire, Friesian, Shorthorn, Red Poll and Jersey. With the exception of the Ayrshire herd which is at Ambawela, the remaining four herds are housed at Bopatalawa. The total number of records analysed in this study consisted of 2,868 lactation records from 871 cows, approximately 36 per cent. of which were Ayrshire, 28 per cent. Friesian, 18 per cent. Shorthorn, 11 per cent. Red Poll and 7 per cent. Jersey.

All five breeds are maintained on a moderately high plane of nutrition, though in the early years of development of the farms conditions were not so satisfactory. In addition to grazing and cut green fodder, all milking animals are allowed on the average, 1 lb. of concentrates to every 2 lb. of milk. Cows in late pregnancy and young stock are also given a liberal allowance of concentrates. The main components of the concentrate ration are coconut poonac, rice bran and fish meal, all of which are produced in the country and therefore available at low cost. Standard mineral mixture is incorporated to the extent of about 3 per cent. of the total concentrate ration of all animals.

RESULTS

The means and variations of the main production traits are presented in Table 1. The mean age at first calving among the European breeds, with the exception of the Jersey, was 40 $\pm$ 0.4 months. The Jersey,

which is represented by a small herd, averaged 30 months at calving. A concentrated effort is now being made to lower the age at first calving by improved feeding and management of young stock. The indications are that a considerable reduction in age at first calving could be attained although it may not be possible to lower it immediately to the level obtaining in European countries.

TABLE 1—Means and Variations

Trait	*Breed*	*Mean*	*Coefficient of Variation*
Age at first calving	Ayrshire	40 months	
	Friesian	40 months	
	Shorthorn	41 months	19%
	Red Poll	41 months	
	Jersey	30 months	
First lactation 305 day Milk yield ..	Ayrshire	377 gls.	
	Friesian	461 gls.	
	Shorthorn	379 gls.	36%
	Red Poll	317 gls.	
	Jersey	279 gls.	
Length of lactation	All breeds	320 days	27%
Calving interval	All breeds	466 days	34%
Dry period	All breeds	135 days	100%

The average first lactation yield has varied from breed to breed and from period to period since the inception of the farms at Ambawela and Bopatalawa. The yield figures presented in Table 1 are for the whole period from 1943 to 1954. They may be compared with average yields during 1954-5 of 511, 625, 463, 462 and 418 gallons respectively in the Ayrshire, Friesian, Shorthorn, Redpoll and Jersey herds. Variations in age at first calving were found to exert a marked influence on the first lactation yield in the Ayrshire and Friesian breeds where the regressions of yield on age at first calving were 6.6 and 11.0 gallons respectively per month.

The mean length of calving interval in the total data was 466 days as shown in Table 1, but in recent years it has been lowered appreciably and the average during 1951-4 was 413 days, which is not very different from that in European cattle in temperate countries. A similar decrease in length of dry period from about 135 days to 100 days has also been achieved.

Perhaps the most interesting feature of Table 1 is the high coefficients of variation obtained for all production traits. These coefficients are almost twice as large as the corresponding coefficients of variation for cattle in temperate countries.

VARIATION OF YIELD WITH AGE

The results obtained by the paired lactation method showed that peak production in the herds at Ambawela and Bopatalawa was generally attained by the third lactation. In the case of European cattle in their home environment, the peak of production is usually later, by about the fourth or fifth lactation. This difference in the age effects of European cattle in temperate countries and in Ceylon may perhaps be due to the late age at first calving of these cattle in the tropics. The average increase in yield from first to second lactation in the present material was 16.5 per cent., and that from second to third lactation 4.2 per cent. Though the former value is rather more and the latter rather less than in European cattle in temperate countries, the overall increase in yield with age is closer to that in Europe than to that in Zebu cattle in the tropics.

CORRELATIONS—LACTATION YIELD, LACTATION LENGTH AND AVERAGE DAILY YIELD

As lactations vary little in length in the more advanced dairying countries, the main factor governing the lactation yield of dairy cattle in those areas is the maximum daily yield. But, with Zebu cattle in the tropics there is generally a high correlation between yield and lactation length as well. One might then ask to what extent these differences between European and Zebu cattle are genetic. The results summarised in Table 2, based on the analyses of data collected for different breeds in Ceylon and also on analyses that we have carried out of records published in *Misc. Bull. I.C.A.R. No. 36 (1941), India,* seem to provide an answer to this question.

TABLE 2—Intra-herd Intra-cow Correlations between Lactation Yield and Lactation Length and between Lactation Yield and average Daily Yield

Breed	*Source of Data*	*No. of records*	*Correlations*	
			Lact. yield and Lact. length	*Lact. yield and average daily yield*
Sinhala ..	Ceylon	333	0·44	0·82
Red Sindhi ..	Ceylon	696	0·60	0·78
Sahiwal ..	Misc. Bull I. C. A. R. No. 36, India	237	0·42	0·79
¼ European × Zebu ..	,,	327	0·51	0·72
½ European × Zebu ..	,,	996	0·49	0·76
¾ European × Zebu ..	,,	519	0·55	0·78
European ..	Ceylon	1566	0·50	0·72

It will be seen from this table that the high correlation between yield and lactation length observed in tropical countries is not a trait that is peculiar to Zebu cattle. It appears to be common to all stock reared under the conditions of management prevailing in tropical areas, irrespective of whether the population is purebred Zebu, purebred European or crossbred. It is therefore improbable that the relationship usually observed between yield and lactation length for Zebu cattle in the tropics is due to the genetic make-up of these cattle.

REPEATABILITY

The within-herd correlation of the yield in one lactation with that in the next for the same cow was found to be 0.5. The corresponding figures for average daily yield and lactation length were 0.4 and 0.27. These figures indicate the extent to which the respective traits are permanent characteristics of the cow. The figure 0.5 for yield agrees closely with the estimates of repeatability of this trait in Zebu and crossbred cattle in the tropics and in European cattle in temperate environments. So that, despite the high coefficients of variation found for milk yield in dairy cattle when reared in tropical countries, a good part of the variation is still due to permanent differences between cows.

With repeatability of the order of 0.5 for lactation yield and 0.4 for average daily yield, culling of cows on the basis of either of these traits, but preferably on the former, could be carried out early in the life of the cow. The intra-herd correlation between the length of one lactation and the next of the same cow (0.27 ± 0.02), though statistically significant in these data, is not sufficiently high to warrant the culling of cows on the basis of length of lactation even if longer lactations are desired. Moreover, since the phenotypic correlation and presumably also the genetic correlation between lactation length and yield is not perfect, selection of cows on lactation length would tend to lower the intensity of selection for yield.

In regard to calving interval and dry period, the intra-herd correlations were found to be 0.15 and 0.07 respectively. It would be seen from these figures and from the rapid decrease in length of calving intervals and dry periods in recent years in these herds, that calving interval and dry period are almost entirely under the control of management and have little or no genetic component. Although this conclusion may appear difficult to reconcile with the results reported for dry period in temperate environments, it is nevertheless

understandable if it is borne in mind that the average length of dry period in the present data is so much longer than optimum that existing genetic variations between cows in length of dry period are more or less completely masked by management factors. The same explanation would account for the low repeatability of dry period in Zebu cattle in tropical countries.

HERITABILITY

It is known that the method of doubling the intra-sire regression of daughter's record on dam's record would give the most reliable estimate of heritability in data relating to dairy cattle production, where, in general, the dams are likely to have been rather more highly selected than the daughters. In the present data, however, there was reason to believe that the intra-sire correlation would provide a more dependable estimate of heritability than the intra-sire regression. For a regression coefficient to be valid, it is important that distribution of the independent variate should not exist or at the most it should be very reduced. In the current data, the coefficients of variation of milk yield in different periods since the inception of the herds were such that the dams appeared to be a more highly variable population than the daughters. Moreover, whatever selection pressure was applied to milk yield during the early years was small, and in consequence the population of dams may be regarded as an unselected lot in so far as milk yields were concerned. The unselected nature of the dams (most of which were imported), when considered in conjunction with their high variability, warrants the use of the intra-sire correlation for estimating heritability in these data, in preference to the intra-sire regression.

Records used for estimating heritability were all standardised for variations in age and for yearly variations caused largely by improvements in management. It was found that the heritability of single records of milk yield in the population was 0.18 when using the intra-sire correlation and 0.16 when using the intra-sire regression. This means that about one-third of the permanent differences or roughly one-sixth of all differences between cows in the population are additively genetic.

Table 3 summarises the results obtained from different studies of the repeatability and heritability of milk yield in purebred Zebu, purebred European and crossbred stock in tropical areas and in purebred European stock in temperate areas. The similarity of the estimates is striking.

TABLE 3—Repeatability and Heritability of Milk Yield in Dairy Cattle in Tropical and Temperate Countries

Breed	*Repeatability*	*Heritability*	*Reference*
Purebred Zebu cattle in Nigeria ..	0·60	0·32	Robertson (1950)
Purebred Zebu cattle in Ceylon ..	0·46	0·20	Mahadevan (1955)
Crossbred cattle in Jamaica ..	—	0·24	Lecky (1950)
Crossbred cattle in India ..	0·53	0·19	Mahadevan (1954)
Purebred European Cattle in Ceylon	0·51	0·18	Current data
Purebred European Cattle in temperate countries	0·5	0.2–0.3	Most studies

GENETIC CHANGES IN THE HERDS

Any attempt to improve the genetic level of a herd of dairy cattle is basically dependent on the prevailing mortality rates, rearing proportions and total reproductive rates. With high reproductive and low mortality rates and with high rearing proportions, the intensity of selection possible would be high, and vice-versa. In the present study, it was found that during the period prior to 1951 the average reproductive rate, when measured as a sum of the partial reproductive rates in the different years, was 0.38. This means that, on the average, about every five cows produced in their lifetime two heifer calves that came into milk in the herd. Rearing proportions were also low, and it was only once in about 5 calvings that a cow produced a heifer calf which reached a lactation in the herd. Associated with this was the high mortality rate that prevailed in the herds during this period. In fact, of every 100 heifers born at that time, 39 died before first calving.

In the light of this, it is not surprising that in the majority of these herds no overall genetic progress in milk production was made up to 1950 by selection of dams of heifers. During the period after 1950, however, when the average mortality rate among heifers was reduced to 24 per cent., and when total reproductive rates increased to 0.68, the intensity of selection possible has been greater and a positive selection pressure appears to have been exerted in practically every herd. This is reflected to some extent in the high lactation yields now obtaining at Ambawela and Bopatalawa.

The sires used until 1950 were all imported, and it is only in recent years, with the introduction of a programme of progeny testing young bulls in the large Ayrshire and Friesian herds, that

farmbred bulls are being used. In order to keep generation intervals as low as possible, young bulls earmarked for testing are reared on a high plane of nutrition during early life so that they are in fit bodily condition for service when they are about 1½ years of age. This aspect of dairy cattle management is of some importance in the tropics where age at first service in males and age at first calving in females tend to be delayed in most herds. The mean generation interval in the present material ranged from 3 years 9 months in the Jersey herd to nearly 7 years in the Red Poll, with an overall mean of 5 years.

DISCUSSION

It is well known that the causes of variation between individuals are differences in the heredity with which they started life, and differences in the environments, both known and unknown, that affect them during their development. The proportion of the variation attributable to each of these two causes differs from trait to trait and from population to population. For characteristics of economic importance in farm animals, such as milk production and other associated traits in dairy cattle, there is generally a high degree of variation.

Although the bulk of the work on the analysis of variation in dairy cattle production has been conducted with European stock in temperate countries, the few studies that have recently been made of tropical dairy cattle serve to emphasise the considerably greater variability obtaining in the latter material. One might therefore ask whether the greater variation within tropical breeds is due to greater differences in the heredity of the animals comprising the breed or to greater differences in the environment to which they are exposed. The results obtained here, when considered in conjunction with previous work on European, Zebu, and crossbred stock suggest that the latter is much nearer what happens than the former.

This conclusion is borne out to some extent by the coefficients of variation obtained in the present study. Although these data relate to purebred European cattle, the results on variability resemble more closely those found for Zebu cattle in the tropics than those for European cattle in temperate countries. The within-breed coefficient of variation of age at first calving, for instance, is 19 per cent. in the present material, as compared with about 10 per cent. for dairy cattle in temperate areas. Similarly, the coefficients of variation of lactation yield, lactation length, average daily yield, calving interval and dry period, which are approximately 36 per cent., 27 per cent.,

34 per cent., 34 per cent. and 100 per cent., respectively in the present data, are of the same order as those found for Zebu cattle in Ceylon, but almost twice as large as those found for dairy cattle in European countries. The conclusion may therefore be drawn that differences in the extent of variation in most economic characters between stock reared in tropical and temperate countries, are due more to differences in husbandry than to any great inherent differences between tropical and temperate breeds of cattle.

That the genetics of milk production in tropical dairy cattle is fundamentally very similar to that of temperate zone cattle is further evidenced by the similarity of the estimates of repeatability and heritability of milk yield arrived at for purebred Zebu, purebred European and crossbred stock in tropical areas, and for purebred European stock in temperate areas. These results are summarized in Table 3.

But there appears to be one important difference between European and Zebu cattle that cannot be entirely attributed to management, and that is the effect of age on yield. In the Zebu, the effect of age on yield is generally much less than it is in European cattle. Among Zebu breeds in Ceylon such as the Red Sindhi, the increase in yield from first to fourth lactation is only 6 per cent. This may be compared with values ranging from 19 to 32 per cent. in the present herds and with similar figures for European cattle in temperate countries. Although part of the differences in the age-changes of European and tropical cattle may be due to management factors, it appears likely that variations in the extent to which the two groups of cattle have been selected for milk production since the time of their domestication may also play some part.

Be that as it may, the differences between European and Zebu stock in regard to most of the parameters that have been calculated here appear to be rather of an animal husbandry than of a genetic nature. It would seem therefore that with the gradual advancement of husbandry techniques in tropical areas, the genetic situation among cattle in the tropics could be more clearly shown to follow the pattern in European dairy countries.

SUMMARY

The existence of a high degree of variability in all production traits of cattle in tropical countries has been demonstrated. Evidence has been adduced to show that this is due more to increased environmental variability than to any great inherent differences between

animals. The conclusion is drawn that despite minor differences, the genetics of milk production in tropical dairy cattle is fundamentally very similar to that in European stock.

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