PRODUCTION LIMITATIONS ARISING FROM THE TYPE OF DAIRY ANIMALS AVAILABLE IN TROPICAL AUSTRALIA

1. REVIEW OF THE LITERATURE

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INTRODUCTION

A major problem of breeding dairy cattle for the tropics has been the probability that high dairy production and adaptability to the tropics were incompatible. This suspicion was based on the generally low production of breeds of cattle which were well adapted to the tropics and on a vague physiological relationship such that high dairy production involves much metabolic work and consequently releases much surplus heat to be dissipated and that a prominent part of homeostasis in the tropics was the animal's ability to keep its body temperature below a certain level to enable it to eat. To this must be added the problems of the husbandryman in controlling diseases, particularly that of controlling parasitic diseases, and the problems of the poor quality of forages offered to cattle in these environments.

Generally as far as tropical breeds are concerned, their problems are solely those arising from their inherently low milk production, late age at first calving, long calving intervals and short lactations (Mahadevan 1958).

Milk production figures for Queensland, N.S.W., Victoria, South Australia and Tasmania are shown in Table 1, (B.A.E. 1966). It shows that milk production is lower in Queensland and Northern N.S.W. than in Southern N.S.W., Victoria, South Australia and Tasmania. The differences in production between Northern Queensland and the Darling Downs are not as great as one would expect if this were solely due to higher temperatures.

TABLE 1

3-year average milk production 1961-62 to 1963-64 (B.A.E. 1966)

District	Milk Production (kg)
Queensland Downs	1905
Northern Queensland	1496
South-west N.S.W.	2154
Northern N.S.W.	1465
Victoria Gippsland	2907
South Australia	2503
Tasmania	2394

Differences in production levels between dairy cows in the tropics and subtropics in Australia must relate to the climate, the ability of the animal to eat sufficient food or to the feed offered.

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It has been difficult to demonstrate any relationship between an animal's thermoregularatory powers and its milk production (Rendel 1970). McDowell *et al.* (1969) have concluded that prolonged heat results in a fall in milk production. The digestible energy intake by the animal fell half as much in their experiments as the energy content of the milk produced. The Israelis have found that to achieve high milk production it was necessary to provide extra energy to housed and showered Holstein cattle in the Arava Valley where temperatures range from 22° to 38°C (Kali, Amir and Morag 1970). Ragsdale *et al.* (1948) established critical temperatures of 75°F-80°F for Friesian and 80°F-85°F for Jersey cattle above which milk production, feed consumption and body weight were rapidly depressed. Rees (1964), using small numbers of animals, noticed that cows with the higher milk production were least able to cope with thermal stress conditions as indicated by body temperature increases. He observed a decrease in milk production and a change in milk composition in animals which were heated to 15°F. Johnson (1958) reported that the level of milk production influences the degree of response by cows to hot conditions. Brody *et al.* (1948) and Johnson *et al.* (1954) estimated that for each 1 lb of fat corrected milk production, metabolic heat production increased by 10 kilo calories per hour.

Pasture species grown in the tropics are generally of lower digestibility and may impose direct limitations to dairy production by limiting the quantities of gross digestible nutrients available to cows in the tropics (Mahadevan *et al.* 1968).

TYPE OF DAIRY ANIMALS AVAILABLE

European breeds

Levels of milk production reported in Queensland and Northern N.S.W. are not only below those for the southern states of Australia but are below those quoted for European herds in some tropical areas in other parts of the world. For instance, Friesian cattle in the Arava rift valley, north of the Red Sea port of Eilat, in Palestine, where temperatures range from 22°C to 30°C, have an average milk production of 7310 kg. To achieve this high level of production the cows were housed in properly ventilated barns which provided ample shade for each animal and prior to each milking the cows were cooled by showering. In addition, each cow was fed daily five Scandinavian food units for maintenance and 0.4 food units for each litre of milk produced. In addition, they were fed extra energy in the form of three extra food units per day for about 16 weeks after calving.

In Puerto Rico in 1964, 2500 dairy cattle in the ten leading herds of Holstein cattle averaged 3330 kg of milk (Mahadevan 1966). This was probably produced when animals were grazing on Pangola pastures under coconut trees. Rendel (1970) refers to herds in the southern states of U.S.A. and at altitudes of 4000 ft. in Kenya and Uganda where European breeds perform reasonably well and better than Sindhi and Uganda crossbreds respectively. The Sindhi crossbreds in the southern states of Louisiana, Maryland and Georgia were crosses between Red Sindhi and Jersey, but no selection for milk production had been made. Edwards (1932), Howe (1949) and Lecky (1949), working in the West Indies, agreed that grading up to pure European breeds in the tropics was unsuccessful. The half-breeds were the highest producers among Friesian crosses, whereas among Jersey grades Lecky (1951) showed that there was an increase in milk production up to three-quarter Jersey level. Holstein and Brown Swiss have shown poor ability to adapt to the tropical environment of Columbia which has been reflected in low milk production and poor fertility (Salazar and Waugh 1968). On the other hand, Monieb, Afifi and Ibrahim (1970) showed that when Friesian cattle were crossed with the native cattle of Egypt and these animals were milked in the Nile Delta, the first cross showed a marked improvement, and by increasing the Friesian blood in the crosses up to 7/8 Friesian the average yield was increased but at a slower rate.

Tropical breeds

The suggestion by several authorities that European cattle are unsuited to the tropics raised the possibility of introducing dairy cattle from the tropics and selecting them for milk production. The high average yields obtained in the Pusa pedigree Sahiwal herd and some other herds in India have often been used as evidence to support the contention that similar results could be achieved with indigenous breeds of cattle in other parts of the tropics, but Mahadevan (1958) points out that the breed was almost as well developed in the early nineteen hundreds as it was in 1958. Average milk yields of 2000 kg and over which have been reported for breeding herds of Zebu cattle are few and far between. In the majority of Indian herds milk yields have generally been of the order of 1000 to 1500 kg per lactation. Mahadevan (1958) refers to the Red Sindhi herds at Madras and Bangalore which are reported to average over 2000 kg of milk per lactation and at Pollonura in Ceylon which have averaged 1100 to 1200 kg of milk per lactation, to the Hariana herd at Izatnagar which averaged 800 to 1500 kg of milk per lactation and to the Kenana cattle in the Sudan which have averaged 1800 to 2000 kg in a lactation.

From a genetic viewpoint an interesting feature common to all tropical dairy breeds is the great within-herd variation in yield. Those reported by various authors vary from 40% in Red Sindhi cattle in Ceylon (Mahadevan 1955) to 50% in the white Fulani cattle of Nigeria (Robertson 1950). Those can be compared with 20-22% in European cattle milked in temperate areas. However, as Mahadevan (1966) has shown, the variability in milk production of European cattle milked in the central hills of Ceylon is just as great as that of the Zebus. Heritability estimates for milk production have been calculated in a number of herds of indigenous cattle. Estimates for the heritability of milk production range from 0.20 to 0.40. Most have been calculated on relatively small herds of cattle, but they are similar to those reported for European cattle. Thus the evidence is good that heredity plays a considerable part in determining the variation in milk production in tropical cattle.

There are still a number of things concerning milk production capacity in tropical cattle which are not understood. Among these, probably the most important factor is the "temperament" factor involving a "holding back" of milk which is present in the first lactation of many Zebu breeds. There is considerable evidence that this has a genetic basis (Hayman—personal communication) so that selection against this character should be possible.

Mahadevan (1958) has calculated from the report by Faulkner and Brown (1950) that there was an increase in production in the "best" lactation averages for the Nandi cattle in the Baraton herd in Kenya of 93 kg of milk in 15 years or an annual rate of 0.8 to 0.9% in milk production per lactation. However, most of this he attributed to improved husbandry methods over these years at Baraton. Mahadevan has concluded that percentage genetic improvement is not very encouraging for tropical dairy breeds when viewed in terms of the absolute increase in yield which they signify.

Crossbreds

It would appear from the foregoing that neither the pure European nor any of the tropical cattle breeds provide the complete answer to dairying in the tropics. European breeds will not produce to their potential because of high temperatures, disease and poor diet. Tropical breeds are well adapted to all these factors, but are low milk producers, are late maturers and have long calving intervals and short lactations. Rendel (1970) has suggested that a cross should be made between a European and a Tropical breed which should be improved for production and adaption.

Although there are many crossbreds, in projects around the world very few have been fully reported. There are two such crossbreeding experiments in progress in Australia, but neither have reached a stage at which full progress can be reported. Alexander and Byford (1970) have reported progress in the development of a tropical dairy breed at Ayr in Queensland based on crosses between Sahiwal, A.I.S., Friesian and Jersey, in which 15% of animals are capable of lactations of up to 300 days and yield up to 160 kg of butterfat and 4500 kg of milk. The milk production for their ¼-bred, ⅜-bred and ½-bred Sahiwal crossbreds at Ayr are shown in Table 2 (Byford—personal communication). Some difficulty was experienced at Ayr with the milking routine and to some extent the first lactations were affected. Eleven half-bred Sahiwals transferred to Kairi, on the Atherton Tablelands, in 1969 have shown remarkable persistency (270 day lactation), but yields are about 2/3 of the pure Friesian herd grazing the same type of tropical grass-legume pasture (Byford—personal communication). Rendel (1970) has described another experiment based on crosses between Red Sindhi and Sahiwal and Jersey, Guernsey, A.I.S., and Friesian cattle. The males are selected from high producing cows and are selected for heat tolerance and tick resistance before undergoing a progeny test. So far the daughters of the unselected ½ Jersey x ½ Zebu bulls have yielded a little better than contemporary Jerseys and heritabilities of milk yield have been of the order of 0.65 and 0.70. Of the few recorded crossbreeding experiments the most successful is the Jamaican Hope breed (Wellington, Mahadevan and Roache 1970). The Bodles herd, composed of Jamaica Hope cows, averaged 3220 kg of milk from 1950 to 1964 and its first lactation average increased from 2500 kg of milk in 1950-54 to 3028 kg in 1960-64.

TABLE 2

Milk production of Sahiwal crossbreds at Ayr 1964-65 to 1969-70

	¼ bred		⅜ bred		½ bred	
Year	No. Cows	Kg Milk	No. Cows	Kg Milk	No. Cows	Kg Milk
1964–65	18	465			14	1186
1965–66	13	142	1	1748	18	996
1966–67	14	387	8	282	20	999
1967–68	9	841	5	1480	20	1362
1968–69	16	1046	14	2023	28	1867
1969–70*	15	1641	12	1297	13	2013
1969–70					11	2713

*At Kairi

TICK RESISTANCE

Statistical information on the effect that cattle tick has on milk production of dairy cows is lacking. However, its effect on liveweight gains in beef cattle (Francis and Little 1964) would suggest an effect on milk production also. It is now apparent in Australia that the development of resistance by cattle tick to acaricides is only at the best one acaricide ahead and in time it seems probable that even this advantage may disappear.

The logical approach to tick control would therefore appear to be the development of breeds of dairy cattle which are resistant to ticks. Many reports of the resistance of Zebu cattle and their crosses to the cattle tick have been published (e.g. Kelly 1943; Reik 1962; Francis and Little 1964; Hewetson and Nolan 1968). Wharton, Utech and Turner (1970) have reported on the tick resistance of A.I.S. cattle. There is evidence also of the development of resistance by purebred Sahiwals

(Hewetson 1971) and their crosses (Hewetson and Nolan 1968) and reference has been made to tick resistance tests in the development of a breed of Sahiwal crossbreds at Lismore (Rendel 1970).

There is strong evidence that resistance by cattle to cattle ticks is inherited (Hewetson 1968; Wharton, Utech and Turner 1970; Seifert 1971). Estimates of heritabilities of tick resistance were similar for A.I.S., Sahiwal crossbreds and Herefords and Shorthorns, but lower than those for F3 Zebu crossbreds (Seifert 1971).

In selecting dairy cattle to reduce the limits imposed by the cattle tick there would again appear to be these alternatives:—

1. To select within the British breeds
2. To introduce tick resistant breeds and select for milk production
3. Cross a tick resistant breed with a European breed.

The development of strains of dairy cattle within a European breed is possible, e.g. A.I.S. cattle (Wharton, Utech and Turner 1970).

There appear to be many resistant animals within the Jersey breed (Lewis and Hewetson unpublished), but there is insufficient information about resistance within the European dairy breeds to completely discard the possibility of selecting resistant strains from amongst their number. It would seem worthwhile that more investigations should be directed to discovering the tick resistance of the various dairy breeds. A more immediate answer to the problem would be to cross the milk producing and tick resistant breeds and to select for milk production and tick resistance from within them.

CONCLUSIONS

1. Limitations exist in the choice of dairy cattle for the tropics.
2. Milk production of European breeds of dairy cows appears to be limited by high temperatures, poor nutrition and disease. These limits can be extended if animals are maintained in an artificially cooled environment and are fed extra energy.
3. Milk production of tropical breeds of dairy cows appears to be limited by their inherent low production, their late maturity and long calving intervals.
4. With the development of acaricide resistant ticks it may be necessary to make special provision for tick resistant dairy breeds.
5. Crosses between European and Tropical breeds appear more suited to the tropics, but it will be necessary to select for milk production, heat tolerance and parasite resistance, to achieve the milk production of European cattle in the temperate areas.

REFERENCES

ALEXANDER, G. I., and BYFORD, I. (1970)—Proc. 18th Int. Dairy Congr., Sydney. p. 490.

BUREAU OF AGRICULTURAL ECONOMICS (1966)—The Australian Dairy Industry. An Economic Survey 1961-62 to 1963-64, Canberra, A.C.T.

BRODY, S., WORSTEL, D. M., RAGSDALE, A. C., and KIBLER, H. H. (1958)—Mo. Agric. Exp. Stn. Bull. 424.

EDWARDS, J. (1932)—*J. Dairy Res.* 3: 281.

FAULKNER, D. E., and BROWN, J. D. (1950)—Report by Kenyan Government to F.A.O. Conference, Lucknow, cited by Mahadevan (1958). Tech. Comm. No. 11 Commonwealth Bureau of Anim. Breed. and Genetics, Edinburgh, Scotland (1958).
FRANCIS, J., and LITTLE, D. A. (1964)—*Aust. Vet. J.* **40**: 247.
HEWETSON, R. W. (1968)—*Aust. J. Agric. Res.* **19**: 323.
HEWETSON, R. W. (1971)—*Aust. J. Agric. Res.* **22**: 331.
HEWETSON, R. W., and NOLAN, J. (1968)—*Aust. J. Agric. Res.* **19**: 497.
HOWE, J. W. (1949)—Trop. Agriculture (Trin), cited by Mahadevan (1958). Tech Comm. No. 11 Commonwealth Bureau of Anim. Breed. and Genetics, Edinburgh, Scotland.
JOHNSON, H. D. (1958)—*J. Dairy Sci.* **41**: 744.
JOHNSON, J. E., BRANTON, C., MILLER, G. D., FRYE, J. B., and VIZINAT, J. J. (1954)—cited by Rees (1964)—Dept. of Agric. Tas. Res. Stn. Bull. 4.
KALI, J., AMIR, S., and MORAG, M. (1970)—Proc. 18th World Dairy Congr., Sydney. p. 494.
KELLY, R. B. (1943)—C.S.I.R.O. Bull. No. 172.
LECKY, T. P. (1949)—Bull. Dept. Agric. Jamaica, N.S. No. 42. Cited by Mahadevan, P. (1958). Tech. Comm. No. 11 Commonwealth Bureau of Anim. Breed. and Genetics, Edinburgh, Scotland.
LECKY, T. P. (1951)—Tech. Comm. No. 11. Commonwealth Bureau of Anim. Breed. and Genetics, Edinburgh, Scotland. Cited by Mahadevan, P. (1958).
MAHADEVAN, P. (1955)—*J. Dairy Sci.* **38**: 1231.
MAHADEVAN, P. (1958)—Tech. Comm. No. 11. Commonwealth Bureau of Anim. Breed and Genetics, Edinburgh, Scotland.
MAHADEVAN, P. (1966)—*Trop. Sci.* **9**: 5.
MAHADEVAN, P., DAVIDSON, J. G., COWLISBOW, J. J., SCALE, A. G., LONG, P. S., and JOHANSSON, H. E. (1968)—Proc. 2nd World Conference on Anim. Prod., Maryland. p. 398.
MONIEB, A., AFIFI, Y., and IBRAHIM, Y. (1970)—Proc. 18th Dairy Congr., Sydney. p. 491.
MCDOWELL, R. E. (1966)—Cornell Int. Agric. Mim. No. 17.
MCDOWELL, R. E., MOODY, E. G., VAN SOEST, P. J., LEHMAN, R. P., and FORD, G. L. (1969)—*J. Dairy Sci.* **52**: 188.
RAGSDALE, A. C., BRADY, S., THOMPSON, H. J., and WORSTELL. D. M. (1948)—Mo. Agric. Stn. Res. Bull. 425.
REES, H. V. (1964)—Dept. Agric. Tas. Res. Stn. Bull. 4.
REIK, R. F. (1962)—*Aust. J. Agric. Res.* **13**: 532.
RENDEL, J. (1970)—Proc. 18th World Dairy Congr., Sydney.
ROBERTSON, A. (1950)—Conference on the improvement of livestock under tropical conditions, Dec. 1950, Edinburgh, Scotland.
SALAZAR, J. J., and WAUGH, R. K. (1968)—Proc. 2nd World Conf. Anim. Prod. Maryland. p. 484.
SEIFERT, G. W. (1971)—*Aust. J. Agric. Res.* **22**: 159.
WELLINGTON, K. E., MAHADEVAN, P., and ROACHE, K. L. (1970)—*J. Agric. Sci.* **74**: 463.
WHARTON, R. H., UTECH, K. B., and TURNER, H. G. (1970)—*Aust. J. Agric. Res.* **21**: 163.