annually experienced disappeared in 1927. This notable decrease of ticks on Naushon was in marked contrast to conditions on the adjacent mainland—Cape Cod, where ticks were unusually numerous at several different points, hence the influence of climatic conditions may be excluded.

Further observations will be made at Naushon during 1928. It is a great source of satisfaction that a similar and more elaborate experiment with the same strain of *Ixodiphagus caucurtei* is under way in Montana, in the Bitter Root Range, under the able direction of Professor R. A. Cooley (*Medical Sentinel,* December, 1927).

Thanks are due to Dr. L. O. Howard for his kindly offices relative to the introduction of the parasite into this country; to Dr. Henry S. Forbes and the owners of Naushon, for their actual participation in the experiment, hospitality and financial support.

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AN EFFICIENCY FORMULA FOR DAIRY COWS

IN 1901 Jordan[1] called attention to the differences in efficiency of the various species of domestic animals as converters of animal feeds into human food materials. He gave the production of pounds of "edible solids" per 100 pounds of "digestible organic matter" in the ration as, in part, follows:

Animal and Product	Edible Solids
Cow, Milk	18.0
Hog, Carcass	15.6
Calf, Carcass	8.1
Fowl, Egg	5.1
Fowl, Carcass	4.2
Steer, Carcass	2.8
Sheep, Carcass	2.6

These figures still pass current as representing the efficiency of the animal producer. Jordan clearly pointed out that the figures given are average values and subject to considerable variation, according to various conditions of management, and as between individual members of the species.

With respect to milk production by the cow it is well known that the efficiency of production depends to a great extent upon the annual yield of milk. This note presents a formula for the estimation of a coefficient of efficiency based on the weight and annual yield of the cow. It is intended further to suggest the significance of milking capacity in the dairy cow from the standpoint of the future of the milk supply. Foods of animal origin are inherently expensive, and their consumption has always become more or less restricted with increasing population. Naturally, the more efficient the animal converter the less such restriction need apply. The significance of the efficient cow to the people at large may be better appreciated when we realize that about 45 per cent. of all animal foods consumed in the United States come from dairy cattle.[2]

The coefficient here proposed is essentially similar to the ratio of Jordan, but with this modification, that digestible nutrients[3] (D. N.) are substituted for his "edible solids" on the one side, and also for his "digestible organic matter" on the other side. Accordingly the coefficient of efficiency (C. E.) is $100 \times$ (digestible nutrients in milk produced) $\div$ (digestible nutrients in food consumed). How is this coefficient related to the annual milk yield and weight of the cow?

The digestible nutrients of the milk will vary with the quantity and quality of the milk. The richness of the milk may be disposed of by expressing the yield in terms of 4-per cent. (fat) milk by use of the formula,[4] F. C. M. = .4M + 15F, where F. C. M. is fat-corrected milk or 4-per cent. milk, M is the actual milk, and F is fat; all in pounds. One pound F. C. M. = .172 pounds of digestible nutrients; and, therefore (digestible nutrients in milk produced) = .172 F. C. M.

The remaining variable factor in the coefficient may be estimated from Haecker's[5] data. His maintenance standard is, Digestible nutrients for maintenance per year = 2.893 W, where W is live weight of the cow in pounds. His data show[6] that, Digestible nutrients for lactation = .327 F. C. M.

By substitution and a simple transformation we have the formula:

$$\text{C. E.} = 52.6 \frac{\text{F. C. M.}}{\text{F. C. M.} + 8.847\ \text{W}}$$

[1] "The Feeding of Animals."

[2] Pearl, "The Nation's Food." This estimate is based on total calories and allows a small but proper credit for the beef and veal derived from dairy stock. Swine supply another forty per cent. It has been often stated, on the basis of the superior efficiency of the cow and hog, that they will be the surviving animals. From the standpoint of food consumption it might be better to say that they *are* the surviving animals.

[3] Protein + carbohydrates + fat $\times$ 2.25. It might be better to replace digestible nutrients by net energy if our knowledge of the properties of various feeds in this respect were adequate.

[4] *Bul.* 245, Ill. Agr. Exp. Sta.

[5] *Bul.* 140, Minn. Agr. Exp. Sta.

[6] *Bul.* ——, Ill. Agr. Exp. Sta. (in press).

The factor, 52.6, represents the percentage efficiency of the mammary gland itself. The fractional factor shows the proportion of this efficiency which is realized when the additional nutrients required for body maintenance are included. As an example, if the cow weighs 1,000 pounds and her annual yield is 8,847 pounds F. C. M., the maintenance and lactation requirements are equal, and one half of the potential efficiency of the mammary gland is realized by the whole organism; that is, C. E. = 26.3.

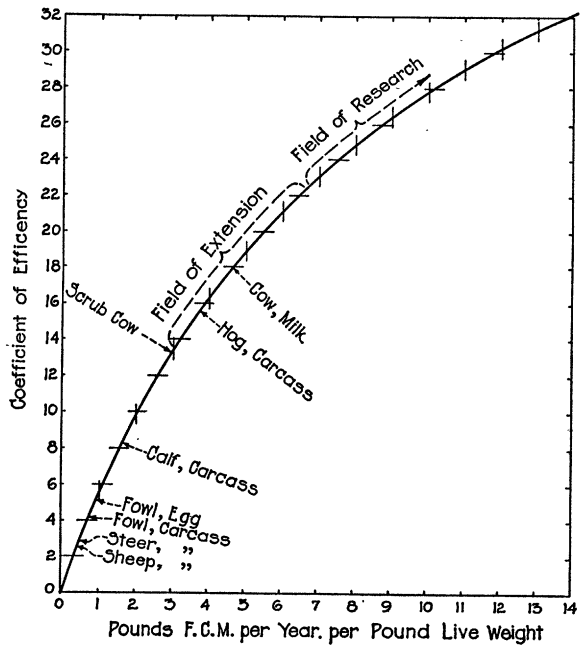

FIG. 1

EFFICIENCY CURVE OF THE COW IN MILK PRODUCTION

The arrows at the right indicate Jordan's average efficiency values for various species. The arrow at the left indicates the average efficiency of the unimproved cow. The first bracket denotes the improvement which may now be readily effected. The second bracket suggests the possibility of still further improvement through the efforts of the breeder and investigator.

Figure 1 illustrates the C. E. curve graphically for yields and weights up to 14,000 pounds F. C. M. per 1,000 pounds live weight. The efficiency values of Jordan, above quoted, are indicated by the arrows at the right of the curve, although they are not strictly comparable with the present formula. It will be noted that the sheep, the steer and the fowl compare in efficiency with a 1,000-pound cow producing 500 to 1,000 pounds F. C. M. per year.

Jordan's efficiency figure for the cow is considerably larger than may be expected of the unimproved animal, whose probable position is indicated by the arrow at the left of the C. E curve. But it is entirely feasible by present known methods of mating and feeding to create and maintain a stock superior in efficiency to Jordan's figure, say up to C. E. = 22 or 23. This may be designated the field of extension, in which so much productive work has been accomplished by the Smith-Lever or corresponding forces of the Land-Grant Colleges, and in which so much still remains to be accomplished. Beyond this there lies the promising field of research in nutrition and in genetics, in which we may possibly hope some day to realize an efficiency of say, C. E. = 30. This, however, is a difficult goal for, according to the formula, C. E. = 30 requires 11,744 pounds of 4-per cent. milk per year per 1,000 pounds live weight, a capacity quite beyond any present certainty of the industry.

Finally, as to the accuracy of the C. E. formula we may consider the very extensive and practical cross-breeding experiments of the Danes. The following figures, adapted from Frederiksen,[7] are the average yearly results for over 1,000 cows during a period of 10 years:

Breed of Cows	Red Danish	Crossbred	Jersey
Weight, lbs.	1021	913	796
Milk, lbs.	7934	6389	5018
Fat, per cent.	3.60	4.28	5.34
Fat, lbs.	286	273	268
F. C. M., lbs.	7458	6657	6027
D. N. in milk, lbs.	1283	1145	1037
D. N. in feed, lbs.	5388	4809	4347
Observed C. E.	23.8	23.8	23.9
Computed C. E.	23.8	23.8	24.3

The C. E. formula is in excellent agreement with these observed average results. As between individual cows we may expect some variability, and the formula may not be expected to apply to some of the advanced registry records of the dairy breeds in this country, where extravagant feeding and delayed breeding have been practiced. But under conservative practices of feeding and breeding (recurrence of conception) it should serve as an index of the relation between yield and efficiency for a given weight.

To determine the milk and fat yields of individual cows is now well recognized as advanced dairy practice. The present formula clearly shows that a record of the weight of the cow as well as her yield is necessary to afford a useful index of her efficiency. Since the weight of dairy cows varies from less than 500 pounds to more than a ton, the weight factor can not be ignored.

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[7] Meddelels 2, Forsøgslaboratoriets Husdyrbrugsafdeling (Copenhagen).