THE STATISTICS OF THE DAIRY.

DR. RAYMOND PEARL is one of the younger generation of American biologists. He belongs to that school of naturalists who pursue, to begin with, the critical study of evolution, dealing not with its results alone but with its actual phenomena, who inquire into the essential facts and ways of working of selection, and who investigate accordingly all the problems, mathematical and other (especially those relating to "probability"), which are associated with variation and heredity. He belongs, that is to say, to the twin brotherhood of the experimentalists and statisticians, and like others of his school he has of late turned his investigations into very practical lines. A batch of Dr. Pearl's recent papers has come to hand, mostly on work done in connection with the Agricultural Experiment Station of the State of Maine. One—a very interesting one—is a general review of "The Selection Problem." Others deal with statistical and biometric methods—for instance with class-frequencies, with the gamma function, and with other matters connected with "curve-fitting." The rest of the batch are for the most part experimental studies, on egg-production or "inheritance of fecundity" in the common fowl, and on various problems of productiveness and of race-inheritance in cattle. Let us consider one only of these papers (or rather a part of one), which deals with "Animal Husbandry Investigations," and in particular with the "Study and Analysis of Milk Records."[1] This is a very practical subject indeed, and all the more so at present, when questions of efficiency in food production are of the highest and most obvious importance.

The essential problem before us is the comparison of two dairies, or two herds, with regard to milk production; how are we to say, or to discover, which herd is the better of the two? Simple as the case at first sight seems to be, it really involves a curious and puzzling statistical problem; for the yield of each individual cow not only depends on its own intrinsic "quality," but is very largely influenced by two distinct factors, namely by the animal's age and by the time which has elapsed since calving. The cow is at her best when about five to six years old; her yield of milk increases up to that age, and slowly falls away afterwards. Whether she be old or young, her yield is at a maximum shortly after calving, and month by month it gradually and slowly diminishes. We must find some means of *equating* our two sets of data for the two herds, when none of the individual data are directly comparable, for the cows in our two herds will differ, at haphazard, in age and in the period elapsed since parturition. We must, in other words, discover some system of "weighting" for these factors, or (what comes to the same thing) some way of adjusting the actual yield to a *standard condition* of age and period. It is obvious, then, that any such calculation must be preceded by a long and comprehensive experimental investigation. After this experimental basis is obtained (and for practical purposes Dr. Pearl has now sufficiently achieved it—unless, perchance, there turn out to be significant differences in the case of Jerseys or other special breeds), the rest is easy; but I have tried (with Dr. Pearl's approval) to simplify his own very lucid account still further, and to employ for this purpose a simple chart or diagram.

As the outcome of all his previous investigations, Dr. Pearl gives us a table of percentage efficiencies in dairy cattle, of which the following is an abbreviation or abstract. We shall not, by the way, carry our discussion beyond the period of ten or eleven months after calving, after which time (provided the cow does not calve again) the yield may still continue a long while, diminishing very slowly in quantity; we must also remember that, for cows ending their lactation in earlier months, the curve will drop somewhat abruptly to zero; and we must not forget that this is a quantitative study only, and that the quality or richness of the milk must be dealt with separately.

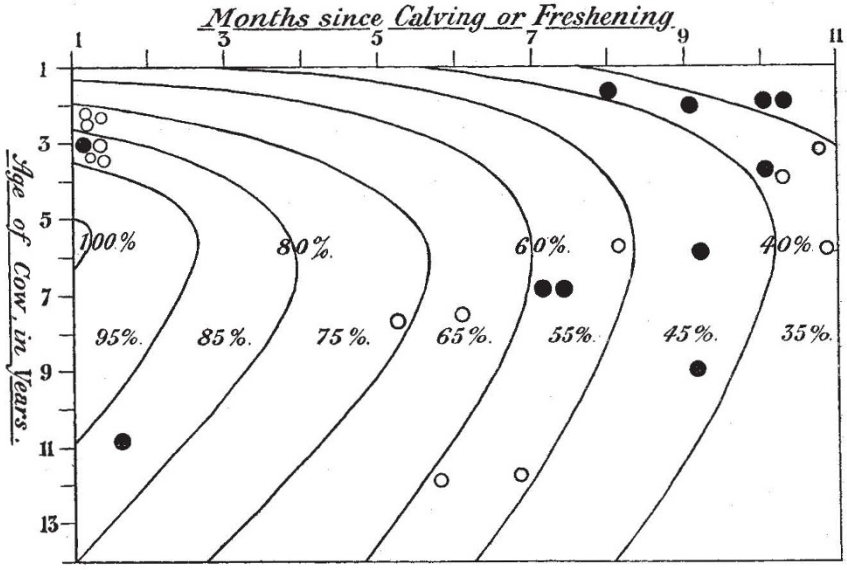

FIG. 1.—Percentage-efficiency chart of milk production. Two herds, A and B, are supposed to have been plotted on the blank chart ●, cows of Herd A; ○, cows of Herd B.

Table of Percentage Efficiencies.

Age of cow, in years	Stage of lactation, in months					
	1	3	5	7	9	11
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1½	58	51	44	37	30	27
3½	93	81	69	56	44	38
5½	100	86	72	59	46	38
7½	99	85	71	57	44	37
9½	94	82	69	55	43	36
11½	88	76	65	53	41	35
13½	82	71	61	50	39	34

From this, or from the full table, we may now prepare our diagram, in which the several contour-lines denote percentages of the maximum or ideal efficiency, 90 per cent., 80 per cent., etc., and the spaces or zones between them represent, therefore, *average* percentage efficiencies of 95 per cent., 85 per cent., etc., as compared with the standard of maximum—this latter being what we should expect were the cow five to six

[1] Report of Progress on Animal Husbandry Investigations in 1915; Maine Agricultural Experiment Station, Orono, Maine. (Papers from the Biological Laboratory, No. 92.)

years old and in her first month of lactation. In order to make use of this chart, then, we proceed to make a mark upon it for each individual cow, each mark corresponding (vertically) to a particular age, and (horizontally) to a particular month of lactation; and this has been done in our figure for two distinct and separate herds, one of fourteen, the other of eleven cows. In short we note upon the chart the cow's age and period, and are then able to read off the corresponding "efficiency" which we are entitled to expect of her. It only remains for us to add up the number of cows (of each separate herd) in each zone or "efficiency class," and then to proceed as follows, by the simplest arithmetic:—

Comparison of Herds A and B.

Efficiency class Per cent.	Herd A: No. of cows	Herd A: Total efficiency Per cent.	Herd B: No. of cows	Herd B: Total efficiency Per cent.
85	2	170	3	255
75	—	0	4	300
65	—	0	1	65
55	2	110	3	165
45	2	90	—	0
35	3	105	3	105
25	2	50	—	0
	11	525	14	890
Average efficiency per cow,	47·7 p.c.			63·6 p.c.
Total yield of milk per day,	260 lb.			290 lb.
Average „ „ per cow,	23·6 „			20·7 „
Standard yield at maximum efficiency	$\frac{100}{47·7} \times 23·6 = 49·4$ „		$\frac{100}{63·6} \times 20·7 = 32·5$ „	

The value which we obtain as our final arithmetical result, viz. 49·4 lb. and 32·5 lb. respectively, for our two herds, may be called the "standard of efficiency," or "standard yield at maximum efficiency," or (for short) the "specific standard" of the herd.

In practice we should have to take into account (as we have not here done) cows that have gone dry, though of an age and period when they should still have been milking; this would introduce a further, but very slight, complexity. Apart from this, and as our broad and simple result, we see (1) that Herd B was operating at a higher efficiency than Herd A, *i.e.* the cows in B were in the better state as regards age and period; but nevertheless (2) Herd A was actually yielding 23·6/20·7, or 14 per cent. more milk per cow; and (3) the most important thing, that Herd A was giving a yield which, when reduced to standard (as though every cow were five years old and newly calved), would be equivalent to 49·4/32·5, or no less than 52 per cent. more milk than Herd B under similar standard conditions. Herd A was one of the best herds of pure-bred Holstein-Frisian cattle in the State, while B was only a fair average or dairy herd.

It is obvious that we may use the same method (with the help of equally easy arithmetic) to determine the value or "efficiency," in comparison with the herd as a whole, of any individual cow. For instance, after we have determined the standard efficiency, or standard yield at maximum efficiency, of Herd A to be 49·4 lb. of milk daily, then a cow the age and period of which place it in the 55 per cent. zone should be yielding something between 50 per cent. and 60 per cent. of that amount, say from 25 lb. to 30 lb. of milk daily. She is not doing her duty by the rest of the herd, and may be weeded out accordingly, if her daily yield of milk be found to be below this quantity.

D'ARCY W. THOMPSON.

AGRICULTURE IN MADRAS.

FEW aspects of Indian administration have manifested more satisfactory advancements than that of agriculture. Since the date of reorganisation of the department into provincial sections (acting under effective Imperial control), since the date when the bulk of the officials under these became expert agriculturists, the improvement has been both substantial and far-reaching. The keynote, moreover, seems to have been the separation of agriculture from revenue. But one can imagine the old Bengal civilian turning in his grave with horror at the abolition of his "Revenue and Agricultural Department," the "et cetera" of former times. To-day the people of India can receive the agricultural official as a friend, free from suspicion of mercenary (revenue) alternatives. No better manifestation of this improved relationship could be given than the appearance of the Madras Agricultural Calendar.

A double page is devoted to each month, from April to March (the official year), and these twelve tables set forth the phases of the moon, the constellations of the stars, the feasts, fasts, festivals, the fairs, shows, exhibitions—all matters of more than ordinary interest to the Indian cultivator. Between the pages of monthly records are interspersed instructive, brief, but practical, chapters on various useful subjects, written by the director, the assistant director, the various deputy directors, and other officials of the department.

The purpose of the Agricultural Department is lucidly set forth; the importance of water to the farmer fully expounded; the merits of the specially selected and improved cotton-seed (here called Sircar cotton) explained and offered for sale; the properties of the Monsoon plough exemplified; the value of superphosphate as a manure for rice explained; then follow suggestive and instructive essays on agricultural engineering; on the conditions under which agricultural loans can be made by the Government; on special crops, such as ground-nuts, guinea-grass, indigo, senna, etc. Next there are given chapters on the improvement of pasture lands, on the Veterinary Department, and on the diseases and pests of crops. The Calendar then supplies particulars of the Agricultural College, the Research Institute, etc., and finally gives a complete enumeration of the departmental and other publications likely to be of value to the farmers.

We commend this excellent little publication (78 pages) as a model of public utility, the more so since it is offered for sale at the humble price of one anna (one penny), and is printed both in English and in the chief vernaculars of the province.

SCIENCE AND INDUSTRY IN SOUTH AFRICA.[1]

OUR Government, I am afraid, has not always fully realised in the past the powerful aid of science and scientific research in general and industrial development. It has been following too much the lead of Great Britain, and has been perhaps too much inclined to regard the scientific departments of the Government as not of primary importance, since they are not immediately productive in the commercial sense. The totally inadequate salaries paid to the *personnel* of Government scientific departments is perhaps an indication of the place which their work has occupied in the general plan of the nation. Only recently a protest was made

[1] From the Presidential Address delivered at the Stellenbosch Meeting of the South African Association for the Advancement of Science, on July 2, by Prof. John Orr.