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Articles in the field of agricultural economics, suitable for publication in the journal, will be welcomed.

Articles should have a maximum length of 10 folio pages (including tables, graphs, etc.), typed in double spacing. Contributions, in the language preferred by the writer, should be submitted in triplicate to the Editor, c/o Department of Agricultural Economics and Marketing, Pretoria, and should reach him at least one month prior to date of publication.

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Contents

Efficiency comparisons between milking parlours and sheds*

by

J.D. GRAHAM, University of Natal

and

J.A. GROENEWALD, University of Pretoria

INTRODUCTION

One of the main reasons for the introduction of milking machines and parlours is the possibility of increased efficiency in labour performance.

Working routines in most types of dairy parlours in South Africa show considerable variation; so also has labour efficiency. This has lead to a study in Natal, in which time and motion techniques were employed to establish optimum working routines in different parlour types and milking sheds.[1] This has also made it possible to compare the efficiency of labour use among parlour types and sheds when optimum work routines are employed. Such a comparison may prove particularly useful to people who have to advise farmers on the choice and construction of new parlours.

The following standards will be used to compare parlour and shed efficiency:

1. Floor space requirements,
2. Basic work cycle time,
3. Unit performance,
4. The man/machine ratio,
5. Man performance, measured in
   (a) cows per man-hour
   (b) pounds of milk per man-hour, and
6. Available feeding time.

The milk pipeline, which is nowadays commonly found in parlours but not in sheds, will in these comparisons be regarded as standard equipment in the parlours, but not in the sheds. Pipelines simplify the pattern of work and result in savings of time.[2] The shed differs from parlours in this respect that in the shed, the cows are stationary and the milking machines are moved from cow to cow. In the parlours, the cows have to come to the machines. The bucket milking unit is here considered standard for sheds.

The carrying of milk from the cows to a central container is a limiting factor in the shed. In none of the parlours is automatic feeding equipment considered standard.

The comparisons will all include parlours with four milking machines. Sheds with space for 50 cows will be considered.

Before discussion can proceed further, certain of the criteria mentioned have to be defined.

EXPLANATION OF SOME EFFICIENCY CRITERIA

The following criteria will be defined or discussed under this heading: basic work cycle time, unit performance, the man/machine ratio and available feeding time.

Basic work cycle time

During milking, the worker's time is spent in repeating a regular sequence of operations on each cow, such as moving to a stall, stripping a cow, letting her out and bringing another one in, preparing the new cow and attaching the cluster to her udder. Such a sequence may be described as his basic work cycle. Times required for these operations in well organised parlours have been measured. These times vary between parlour layouts, milking systems, feeding systems, etc. The basic work cycle time has important effects on the other criteria which follow.[3]

Unit performance

Unit performance is defined as a maximum number of cows which can be milked by one milking machine per hour.[4]

The man/machine ratio

The man/machine ratio gives the optimum number of milking machines per worker. It de-

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* This article is based on a masters' thesis by J.D. Graham at the University of Natal.

1) Graham, J.D., A Study of Work Routines in Milking Parlours and Sheds, M.Sc.(Agric.) thesis, University of Natal, 1966.

2) Vos, H.W., Effort and Time in Pipeline Milking, Netherlands Journal of Agricultural Science, Vol.14, p.47, 1966.

3) See: Graham, J.D. and Groenewald, J.A., The Effect of Milk Yield per Cow on Efficiency of Labour Use in Dairy Parlours, Agrekon, Vol.7, No.4, p.21, 1968.

4) Ibid.

pends on the basic work cycle time, as well as unit-on time and stripping time.[5]

Available feeding time

Available feeding time is defined as the time the cow is able to feed in the parlour or shed. This depends on the time she is stationary in a particular stall.

FLOOR SPACE REQUIRED

The internal dimensions of the parlour types and sheds are presented in Table 1.

When considering total parlour area, the shed is approximately 4½ times as large as the walk-through and approximately seven times as large as the herringbone parlour without feed passages. The herringbone is smaller than any of the other parlour types with two stalls per machine. Estimates of building costs may be made from the dimensions presented.

The work area of the herringbone parlour is much smaller than that of other parlours or sheds, being a bit less than one third of the type with the second smallest work area (the double tandem walk-through). The advantages of a small work area are obvious. Movement by the worker in the herringbone differs from that in the walk-through only by the linear distance travelled when moving from cow to cow on the same side of the pit. In the herringbone parlour, this linear distance is about one third of that in the walk-through.[6]

BASIC WORK CYCLE TIME

In Table 2, three aspects are considered under optimum work routines. These are basic work cycle time, the time during which the milking unit is idle while the worker is busy with his basic work cycle, and the stimulation interval which will prevail under these optimum work routines. As a matter of interest, the average work cycle times encountered on farms, which typically followed work routines other than the optimum, are also presented.

TABLE 2 - Basic work cycle times and related times with optimum work routines in parlours and sheds

	Abreast		Double tandem walk-through	Herringbone	Shed
	One stall per unit	Two stalls per unit			
	Minutes				
Basic work cycle time	2.14	2.14	1.97	1.88	2.97
Unit idle time per cycle	1.61	1.06	1.09	0.33	2.42
Stimulation interval	0.96	0.94	0.99	1.10	1.03
	Performance on farms visited				
Basic work cycle time	2.40	4.57	2.46	1.80	2.77
Number of farms	7	1	2	4	8

It is noticeable that the herringbone parlour has the shortest basic work cycle time and by far the shortest unit idle time. Thus, the worker should normally be able to handle more cows than in other parlour types, and machines are also utilised more fully.

TABLE 1 - A comparison of floor space required in parlours and sheds

	Abreast		Double tandem walk-through	Herringbone		Shed
	1 stall per machine	2 stalls per machine		With feed passage	Without feed passage	
Dimensions (ft.)	23x20	34x20	44x12	26x19	19x18	91x26
Total parlour area (sq. ft.)	460	680	528	494	342	2,366
Work area (ft.)	23x10	34x10	32x6	12x5	12x5	91x9
Total work area (sq. ft.)	230	340	192	60	60	819
Total parlour area per machine (sq. ft.)	115	170	132	123.5	85.4	-

5) Ibid.

6) Lindsey, M.M., The Herringbone Milking System, U.S. Department of Agriculture, Production Research Report 45, 1960.

The double tandem walk-through parlour has a somewhat shorter basic work cycle time than the abreast parlours. Unit idle time per cycle is considerably higher in the abreast parlour if only one stall is used per unit. Basic work cycle time and unit idle time are considerably higher in sheds than in parlours.

The stimulation interval is very important from the point of view of efficient milk ejection.[7] Many work study analysts have not allocated much time to preparation.[8] If a worker is, however, to spend a minute preparing a cow, it is impossible to handle more than 60 cows per hour. Thus, it appears that reports of man performances exceeding 60 cows per hour indicate that too little time is spent on preparation.[9]

UNIT PERFORMANCE

Unit performance is determined by unit-on time and unit idle time.[10] Unit-on time varies with differences in milk yields,[11] but not among parlour types. The differences in unit performance among parlour types is thus the effect of unit idle times. These relationships are illustrated for Jersey and Friesian cows in Table 3 as well as Figures 1 and 2.

As can be seen, the herringbone parlour exhibits the highest unit performances at all yield levels with both breeds. The milking shed consistently fared the worst, while differences among the other parlour types were not large.

TABLE 3 - Unit performance expressed in cows per unit per hour in different parlour layouts and sheds when optimum routines are employed on Jersey and Friesian cows with different milk yield levels

Milk yield, pounds per milking	Abreast		Double tandem walk-through	Herringbone	Shed
	One stall per unit	Two stalls per unit			
	Jerseys				
5	11.3	12.6	12.5	14.8	9.8
10	9.4	10.3	10.2	11.7	8.3
15	8.0	8.6	8.6	9.7	7.2
20	7.0	7.5	7.4	8.2	6.4
25	6.2	6.6	6.6	7.2	5.7
30	5.6	5.9	5.9	6.3	5.2
35	5.1	5.3	5.3	5.7	4.8
	Friesians				
5	12.2	13.8	13.7	16.5	10.5
10	9.4	10.3	10.2	11.7	8.3
15	7.6	8.2	8.2	9.1	6.9
20	6.4	6.8	6.8	7.4	5.9
25	5.5	5.8	5.8	6.3	5.2
30	4.9	5.1	5.1	5.4	4.6
35	4.4	4.5	4.5	4.8	4.1

MAN/MACHINE RATIOS

Calculations of the number of machines which one man can handle in the different parlours, without permitting any over-milking, are presented in Table 4.

The results show that the man/machine ratio does not differ much between parlour types at any yield level with either of the two breeds. The differences are equal to only one machine in most cases, and exceed two in only one instance.

COWS PER MAN-HOUR

Due to the fact that this measure can show such profound variations at different yield levels, it is not a very satisfactory standard of compari-

7) Dodd, C.F. and Foot, A.S., Experiments in Milking Technique, 1. Effect of washing the udder with hot water. 2. Effect of reducing milking time, Journal of Dairy Research, Vol.15, p.1, 1947.
Miller, K. and Petersen, W.E., Some Factors involved in Efficient Milking. Journal of Dairy Science, Vol.24, p.225, 1945.
Dodd, C.F., Foot, A.S. and Henriques, E., Experiments in Milking Technique, 5. Effect of temporary changes in the interval between washing and milking, 6. Comparison of established washing and milking routines, Journal of Dairy Research, Vol.16, p.301, 1949.
Elliot, G.M., The Effect on the Amount of Residual Milk of the Interval between Milkings, Duration of Milking and Delay between Udder Stimulation and Milking, Journal of Dairy Research, Vol.28, p.123, 1961.

8) Chetwynd, K.J., Work Study Applied to the Milking Parlour, Agricultural Review, Vol.1, No.12, p.35, 1956.
Roberts, W.P., Selecting a Milking Parlour for the Individual Farm, Agricultural Review, Vol.3, No.11, p.8, 1958.
Walker, J.K., A Work Study Guide to Machine Milking, Report ICI Work Study Unit E/26, 1959.
McLean, V., Read, S.H. and Thornborrow, B., Better Milking, Journal of the Royal Association of British Dairy Farmers, Vol.65, p.25, 1961.

9) Lindsey, M.M., op. cit.
Easton, P.H. and Harvey, C.N., The Development and Performance of the Herringbone Parlour, with Special Reference to Great Britain, Dairy Science Abstracts, Vol.26, p.401, 1964.

10) Graham, J.D. and Groenewald, J.A., op. cit.

11) Ibid.

TABLE 4 - The maximum number of milking units that can be handled by one man in applying optimum routines in dairy parlours and sheds on Jersey and Friesian cows with different yield levels.

Milk yield, pounds per milking	Abreast		Double tandem walk-through	Herringbone	Shed
	One stall per unit	Two stalls per unit			
	Jerseys				
5	1	2	2	1	1
10	2	2	2	2	2
15	3	2	3	2	2
20	3	3	3	3	2
25	4	3	4	4	3
30	4	4	4	4	3
35	5	4	5	4	3
	Friesians				
5	2	1	2	1	1
10	2	2	2	2	2
15	3	3	3	3	2
20	3	3	4	3	3
25	4	4	4	4	3
30	5	5	5	4	4
35	5	5	6	4	4

TABLE 5 - Number of cows which can be handled per man per hour in different dairy parlours and sheds when optimum work routines are employed on Jersey and Friesian cows with different milk yield levels

Milk yield, pounds per milking	Abreast		Double tandem walk-through	Herringbone	Shed
	One stall per unit	Two stalls per unit			
	Jerseys				
5	11.3	25.2	25.0	22.2	9.8
10	18.8	20.6	20.4	29.3	16.6
15	24.0	17.2	25.8	24.2	14.4
20	21.0	22.5	22.2	28.7	12.8
25	24.8	19.8	26.4	28.8	17.1
30	22.4	23.6	23.6	25.2	15.6
35	25.5	21.2	26.5	22.8	14.4
	Friesians				
5	24.4	13.8	27.4	24.8	10.5
10	18.8	20.6	20.4	23.4	16.6
15	22.8	24.6	24.6	27.3	13.8
20	19.2	20.4	27.2	29.6	17.7
25	22.0	23.2	23.2	29.2	15.6
30	24.5	25.5	25.5	21.6	18.4
35	22.0	22.5	27.0	19.2	16.4

son. These results are, however, presented here because commercial organisations, some time study analysts and researchers in some other fields have used this criterion extensively. Results are shown in Table 5.

Not many conclusions can be drawn from this analysis. It does appear, however, that in four of the seven yield levels with each breed the herringbone parlour fared somewhat better than the others. The shed consistently fared worse than the parlours.

POUNDS OF MILK PER MAN-HOUR

The quantities of milk which can be obtained per man hour at different yield levels in different parlour types are shown in Table 6. These quantities are further illustrated by means of Figures 3 and 4.

The first salient feature of this analysis is the poor performance of the shed compared with milking parlours. Sheds showed lower labour efficiency with both breeds at all yield levels. It also appears that the herringbone parlour produced the best efficiency results at most yield levels. At very high yields however, (35 pounds per milking with Jerseys and 30 pounds or more per milking with Friesians) the double tandem walk-through parlour seems to be better in this respect. These two parlour types seem to yield better all-round results than abreast parlours.

AVAILABLE FEEDING TIME

Available feeding time may be an important factor affecting choice of a parlour. Various reports indicate that concentrate meal can be consumed at a rate of 0.75 pounds per minute; cubes are consumed at a slightly higher rate. The design of the feed manger itself is furthermore an important factor affecting the rate of consumption.[12] Feeding time can, with reasonably good work organisation, not be expected to be in any way a limiting factor in milking sheds. Thus, Table 7 which analyses available feeding time, is concerned only with milking parlours.

Table 7 shows that the higher the yield, the more time is available for feeding. This is a desirable trait in the light that feeding according to production can only be regarded as sound common sense management practice.

12) Read, S., Herringbone Parlour Design, Farm Buildings, Vol. 2, p.32, Spring, 1964.

TABLE 6 - Pounds of milk produced per man-hour in different dairy parlours and sheds when optimum work routines are employed on Jersey and Friesian cows with different milk yield levels

Milk yield, pounds per milking	Abreast		Double tandem walk-through	Herringbone	Shed
	One stall per unit	Two stalls per unit			
	Jerseys				
5	56	126	125	110	49
10	188	206	204	293	166
15	360	258	387	363	216
20	420	450	444	574	256
25	620	495	660	720	428
30	672	708	708	756	468
35	893	742	928	798	504
	Friesians				
5	122	69	137	124	53
10	188	206	204	234	166
15	342	369	369	410	207
20	512	408	544	592	354
25	550	580	580	730	390
30	735	765	765	648	552
35	770	787	945	672	574

TABLE 7 - Available feeding time per cow in different dairy parlour types when optimum work routines are employed on Jersey and Friesian cows with different milk yield levels

Milk yield, pounds per milking	Abreast		Double tandem walk-through	Herringbone
	One stall per unit	Two stalls per unit		
	Minutes			
	Jerseys			
5	4.8	8.0	8.3	7.4
10	5.8	10.1	10.4	9.6
15	6.9	12.3	12.6	11.6
20	8.0	14.5	14.8	13.9
25	9.1	16.7	16.9	16.1
30	10.2	18.8	19.1	18.2
35	11.3	21.0	21.5	20.4
	Friesians			
5	4.4	7.2	7.4	6.6
10	5.8	10.1	10.4	9.6
15	7.3	13.1	13.3	12.4
20	8.8	16.0	16.3	15.4
25	10.3	19.0	19.2	18.4
30	11.7	21.9	22.2	21.3
35	13.2	24.8	25.1	24.1

Available feeding time is much shorter in the one stall per unit layout than in the others. It does not vary to an important extent among the others. This may possibly be regarded as a drawback of the layout with one stall per milking unit.

FINAL EVALUATION OF PARLOUR TYPES

The different parlour types may now be briefly discussed separately.

1. The abreast parlour with one stall per unit

This parlour type has the following disadvantages: although its total parlour area is not excessive, it requires a fairly large total work area; its unit idle time per cycle is high, thus leading to weak unit performances; its man performance is below those of the herringbone and walk-through parlours; available feeding time is limited; most parlours are on one level, thus requiring the worker to squat or stoop and hence leads to unnecessary physical exertion.

An advantage of this parlour type is that cows can be treated as individuals.

2. The abreast parlour with two stalls per unit

When compared with the one stall per unit layout it appears that unit performance of this layout is higher and available feeding time is longer. It requires, however, more floor space.

This layout has the following disadvantages vis a vis the herringbone and double tandem walk-through designs: work cycle time is longer, and more travel is involved; performance is lower as measured by most of the standards; most of these parlours are on one level.

An advantage of this parlour is that it facilitates the treatment of cows as individuals.

3. The double tandem walk-through and herringbone parlour

These two parlour types have some common features and can initially be discussed together. Both of them follow a batch system of handling cows. This has some inherent advantages, in that group handling reduces work cycle time. But they have the important disadvantage that it does not facilitate the treatment of cows as individuals. In both these parlour types use is made of workers' pits, thus making work less tiring. In these

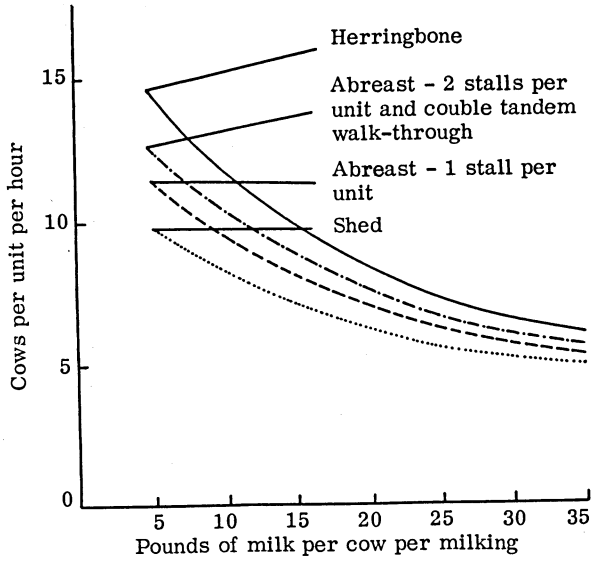

FIG.1 - Unit performances in cows per unit per hour when optimum work routines are used on Jersey herds.

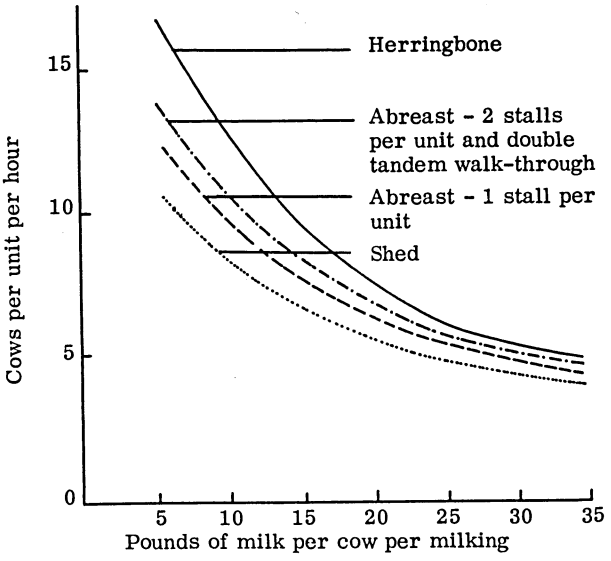

FIG.2 - Unit performance in cows per unit per hour when optimum work routines are used on Friesian herds.

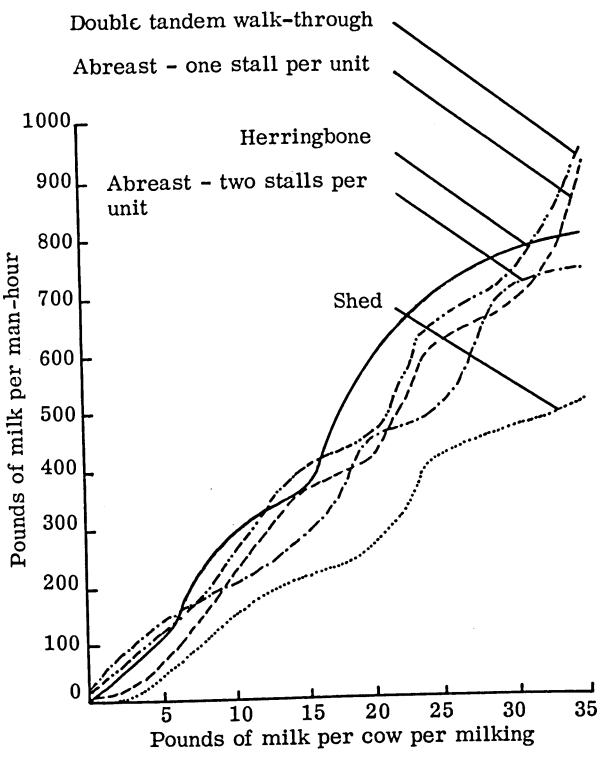

FIG.3 - Pounds of milk produced per man-hour when optimum work routines are used on Jersey herds.

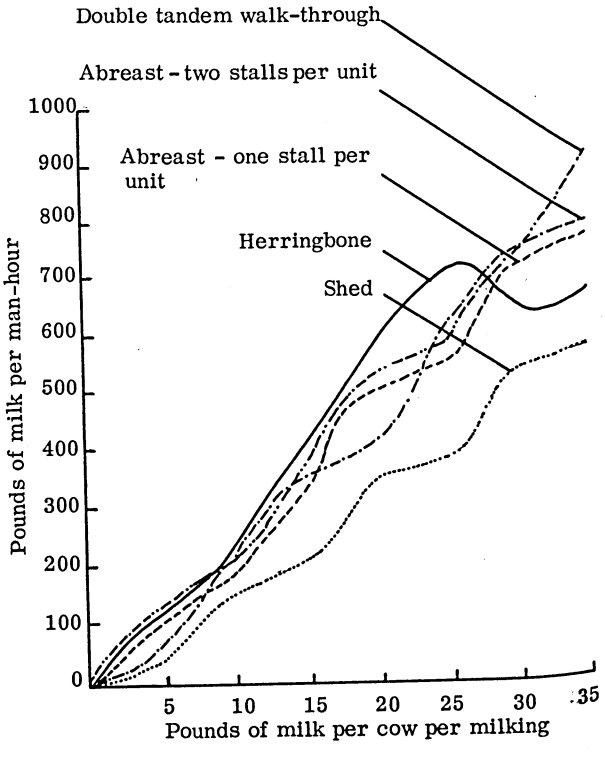

FIG.4 - Pounds of milk produced per man-hour when optimum work routines are used on Friesian herds.

parlours it requires less time to bring cows into the parlour - about 0.20 minutes, as compared with 0.45 minutes in abreast parlours. In general, the above analyses show performances in these parlours to be superior to those in abreast parlours and sheds.

The double tandem walk-through parlour has the following advantages over the herringbone: in the walk-through, workers work as individuals, whereas they have to work as teams in the herringbone. Workers acting as individuals often outstrip team workers in efficiency, and are easier to motivate toward higher performances.[13)]

In the double tandem walk-through parlour, cows are stalled separately, and no poaching of food is possible while this often occurs in herringbone parlours, particularly if the mangers are badly designed or poorly positioned. The lack of separate stalling in herringbone parlours may also lead to a cow being stalled next to one of her "enemies", and thus yielding less milk due to irrigation.[14)] Mechanical feed control is easier and cheaper to install in walk-through than in herringbone parlours.

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13) Taylor, F.W., The Principles of Scientific Management, Harper and Brother, New York, 1911.
Mundel, Marvin E., Motion and Time Study - Principles and Practice, 3rd Edition, Prentice-Hall, Englewood Cliffs, N.J., 1960.
Barnes, R.M., Motion and Time Study, 5th Edition, J. Wiley and Sons, New York, 1963.

14) Duggan, P.W., Modern Trends in Milking Machinery and Service Facilities for Milk Farmers, Paper presented at the 2nd Engineering Symposium, Division of Engineering Services, Pretoria, 1966.

The herringbone parlour has the following advantages compared to the double tandem walk-through parlour: because of the crowding together of the cows, the herringbone parlour requires much less floor space. Building costs can also be expected to be lower. The distances travelled by workers are shorter in the herringbone parlour. Performances tend to be somewhat higher in the herringbone. Slow milkers are less of a problem in the herringbone parlour; the close proximity of cows allows transfer of a unit to a slow milker on the opposite side of the pit. Lastly, also, Easton and Harvey[15)] reported that quite a number of research workers had found that heifers were more readily introduced into a milking herd in a herringbone parlour than in more conventional systems where cows are stalled separately.

4. The milking shed

The analyses presented in this article show clearly that, apart from the fact that feeding time is no problem in milking sheds, performance in the shed is in all respects well below that in the parlour types analysed.

CONCLUSION

The data and other relevant facts presented in this article should be of use to people involved in the planning of milk production systems, particularly to decision makers. Efficiency can be expected to become of increasing importance in dairy farming. Herd sizes may also increase, while labour can be expected to become scarcer and, hopefully, better trained. If this is the case, the double tandem walk-through and the herringbone parlour may be expected to become much more common in future, due to their demonstrated advantages over other parlours and sheds.

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15) Op. cit.