Work Economics and Ergonomics in Dairy Farming

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ABSTRACT

Both the working-time requirement and workload for different milk-production systems are to a large extent determined by stable and yard operations. In this context, the process sequences for milking and feeding chores are of paramount importance. Added to these in future will be the growing proportion of management activities to be accomplished.

The work productivity of a system as a whole can be improved by means of process-engineering, organisational and breeding measures. Process-engineering optimisation works via the increasing mechanisation of work sequences (feed distribution and refilling, automatic remover with swivel arm). In consequence, immediate savings in working time are achieved, whilst work productivity is increased. At the same time, however, there are also usually costs incurred which must be borne in mind.

Organisational optimisation works via a more streamlined structuring of work with improved job organisation (e.g. outsourcing of work processes) and time planning (e.g. briefing, clear goals, further education). It also has a direct, or even indirect, positive influence on working-time requirement and productivity. The consequences in terms of cost, however, are substantially less than with process-engineering optimisation.

Unfavourable body postures in combination with masses to be moved manually have a negative influence on work quality. To date, simple aids for ergonomic analysis and evaluation of stable-and-yard-work procedures have been lacking. Used together with the calculation of the working-time requirement of various milking processes, the expanded OWAS method with its mass-related load index is therefore a helpful tool for recording work processes quickly and easily, and evaluating their ergonomic components.

The incorporation of all components of interest in a work-economics context (time requirement, load, productivity and ergonomics) in a work-budget system allows for the extensive classification of any agricultural work process right up to the whole-farm and sectoral level.

Keywords: working time requirements, workload, time planning, milking, work budget, Switzerland

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1. INTRODUCTION AND METHOD

On modern dairy-cattle farms, precise work-economics planning data are of the greatest importance for each individual work process. They enable farmers to identify the potential for streamling operations and thus to make optimum use of the perennially expensive and scarce resource of labour.

Within the framework of a project, basic work-economics data for dairy-cattle husbandry were recorded. Data collection took place on dairy farms in Germany and Switzerland. The herd sizes studied varied between 18 and 2400 dairy cows, with annual milk yields of between 5500 and 10,500 kg. A total of 124 farms were available for the investigations. Of these, 38 farms were selected at random for the time measurements. On each of these farms a detailed questionnaire was created to provide a picture of the how work was organised (e.g. number of manpower units, state of the labour force) and of the important influencing factors (e.g. number of dairy cows, milk yields, milking method).

Working times were causally collected using the time-element method in the form of direct measurements made during observations of work on the individual farms studied. Repeated measurements were performed both in the area of summer and winter situations as well as during evening and morning milking.

For the milking method, special focus was placed on herringbone milking parlours (HMP), side-by-side milking parlours (SbS) and rotary milking parlours (ROT). In addition, tandem (TD) and auto-tandem (ATD) milking parlours as well as pipeline milking plants (PMP) were included in our studies. The smallest type of milking parlour that we investigated had three milking units (MUs), whilst the largest milking parlour was run with 60 MUs.

All in all, 210 time studies were prepared during the course of the project, with the essential cyclical work elements being recorded in several thousands of repetitions, in order to enable very reliable statements to be made here (see Tab. 1).

Tab. 1. Overview of the number of measured cyclical work elements using the example of milking (extract).

	Milking – Routine Tasks			
Work element	Strip udde	Clean udde	Attach MU	Dip teats
Number of measurements [n	3853	4193	4784	3566

2. ANALYSIS AND MODEL CALCULATION

For further processing, the data gathered was first edited in tabular form and then examined with problem-neutral test procedures (normal distribution, outliers, randomness). Where normal distribution was absent, a one-sided logarithmic transformation was carried out as a basis for the problem-oriented test procedures and regression calculations. All tests were performed with the statistics software Regressa 5.0.

The analysed data were then transferred in the form of budgeted- working-time values and -functions to a budgeted-working-time database table, with each element being assigned a unique alphanumeric code, a name with beginning and end points, and the appropriate statistical parameters, including content description, author and date of creation.The further calculation of working-time-requirement values on the work-process level was performed with the PROOF Model Calculation System (see Tab. 2).

Tab. 2. Structure and approach when modelling work-economics key figures with a model calculation system (Schick, 2006).

1)	Define work process (database)
2)	Define workflow model (database)
3)	Generate list of variables and auxiliary variables (database)
4)	Link variables or auxiliary variables with reference quantities
5)	Link decision-making models with reference quantities
6)	Generate results table or results graphic
7)	Generate information area

This involved the logical linking of work elements with the quantitative and qualitative influencing factors affecting them. All influencing factors were used in the model calculation system as variables, and could be modified at any time within the upper and lower bounds. For all dairy-cow-husbandry work processes studied, herd size proved to be a significant influencing factor. In addition, the number of milking units used and the milking-parlour facilities played a major role for milking. By contrast, for the work procedure of ‘feeding’, the number of components used as well as the method of refilling of feed were of decisive importance.

The model calculation system is modular in structure, and in addition to the budgeted-working-time database, consists of the modules ‘list of influencing factors’, ‘interconnection area’ and ‘output area’. A separate extract from the planning-time database is created for each relevant work procedure, whereby a workflow model is simultaneously defined. A list with influencing factors is then generated and logically linked with the workflow model. After this linking, the output area is created in the form of results tables and/or results graphics. This simultaneously sets up an information area with essential details on the current work procedure. All data are available in freely selectable formats for further processing.

3. SELECTED RESULTS: MILKING

The work processes for milking comprise setting up and cleaning times, routine-task times, and travel times, as well as any waiting times, if applicable (see Fig. 1).

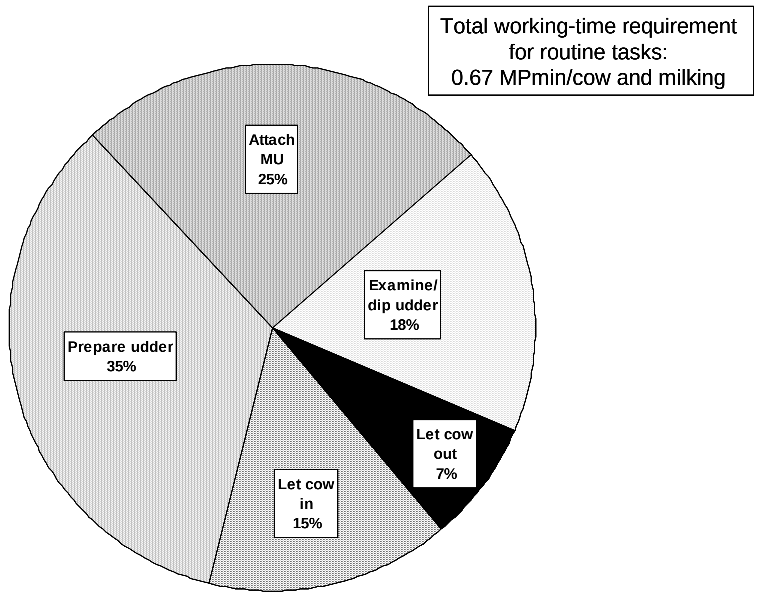

Fig. 1. Routine tasks in milking. (Example: 2 x 12 herringbone milking parlour, 120 cows, highly automated).

They differ according to animal-housing and milking method, but the organisation of work on the individual farm as well as the mechanical and electronic work aids used should also be borne in mind. Routine tasks account for the highest proportion of time spent on milking jobs, and differ considerably among the individual milking methods. Working from this assumption, potential savings can be highlighted. This can be illustrated by comparing a herringbone milking parlour with a rotary milking parlour: by automating the subtasks ‘let cow in’ and ‘let cow out’, almost 25% of the total routine-task time can be saved. With an assumed herd size of 400 dairy cows, this means a potential savings of 68 MPmin per milking (see Tab. 3).

Tab. 3. Overview of routine-task times for different highly automated milking methods (details in MPmin/cow and milking).

Milking method/ No. of MUs	**PMP 3 MUs**	**TD 2 x 2**	**ATD 2 x 3**	**HMP 1 2 x 3**	**HMP 2 2 x 5**	**HMP 3 2 x 12**	**SbS 1 1 x 4**	**SbS 2 2 x 12**	**ROT 16 MUs**	**ROT 40 MUs**
Herd size[No. of cows]	30	40	60	30	60	120	25	120	120	400
Let cow in	0	0.26	0.03	0.33	0.21	0.1	0.29	0.11	0	0
Strip udder	0.14	0.12	0.12	0.11	0.11	0.11	0.10	0.10	0.10	0.10
Clean udder	0.40	0.22	0.28	0.23	0.23	0.12	0.09	0.09	0.13	0.13
Attach MUTeat	0.28	0.20	0.23	0.21	0.21	0.17	0.23	0.23	0.15	0.13
disinfection	0.14	0.12	0.14	0.13	0.13	0.12	0.11	0.11	0.11	0.11
Let cow out	0	0.22	0.04	0.23	0.18	0.05	0.19	0.05	0	0
Total	**0.96**	**1.15**	**0.84**	**1.24**	**1.07**	**0.67**	**1.00**	**0.69**	**0.49**	**0.48**

Without the work elements:: - Stimulate udder
- Adjust MU
- Hang up hose strap
- Strip udder by machine
- Remove MU
- Examine udder

4. WORKING-TIME REQUIREMENT FOR PRODUCTION PROCESSES

Three herd sizes of 40, 120 and 1000 dairy cows respectively were selected for the comparison of different dairy-cow-husbandry production systems from the work-economics perspective. Farms with herds of 40 and 120 dairy cows are run as family businesses without outside labour. By contrast, farms with 1000 dairy cows employ paid labour. Our results clearly showed that, regardless of herd size, tied housing always accounted for the highest working-time requirement. All loose-housing systems required less work. The production processes involving grazing in summer and preserved fodder in winter occasioned more work than those with year-round feeding of silage (see Fig. 2).

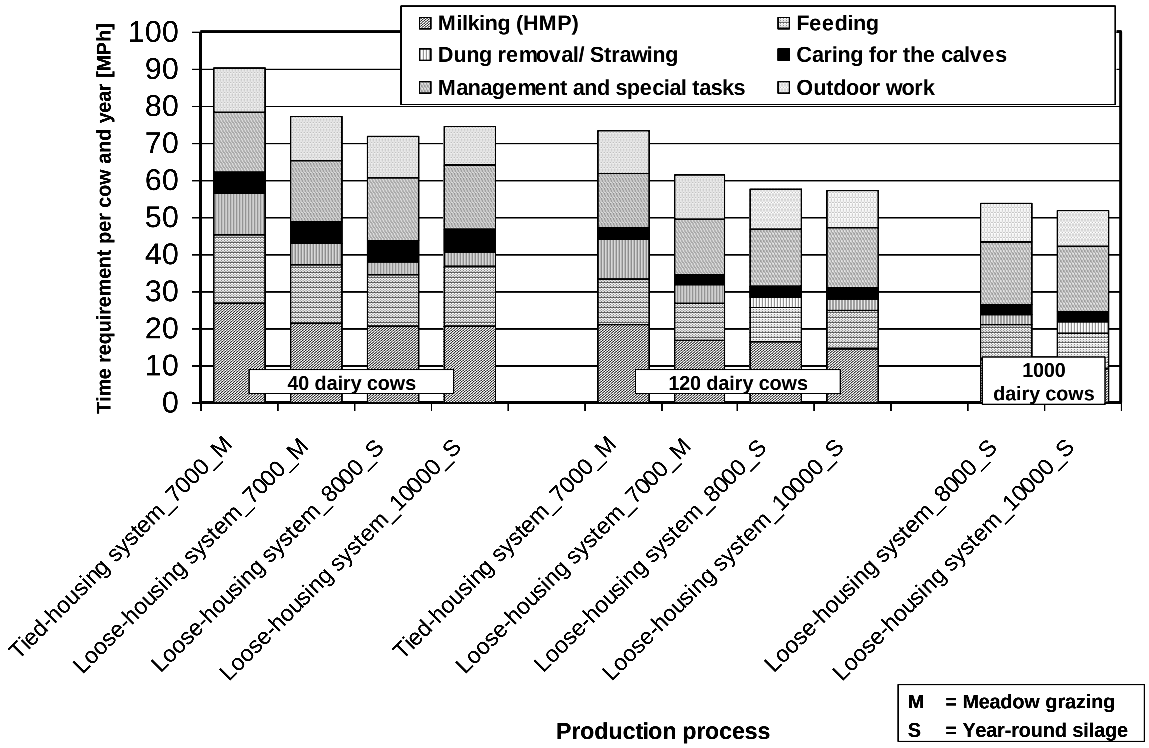

Fig. 2. Working-time requirement for various dairy-farming production methods (7000, 8000, 10000 = Herd milk yield in kg; M = meadow grazing in summer; S = year-round feeding of silage).

With a change in herd size from 40 to 120 cows, the savings in working time per cow and year in these systems is between 14 and 17 MPh or 19-20%. With a further increase to 1000 cows, the possible savings drop to 4-5 MPh per cow and year, or 7-10%. The potential savings are primarily attributable to cutbacks in the number of workers as well as improved use of manpower in milking tasks. This additional savings effect is only achievable, however, when stalls are optimally laid out with short routes for all those involved (milkers, cows and cow-herders).

5. PHYSICAL WORKLOAD

Physical workload varies considerably according to milking method (see Fig. 3). In tied housing, the milker spends the majority of the milking time in an unfavourable posture.

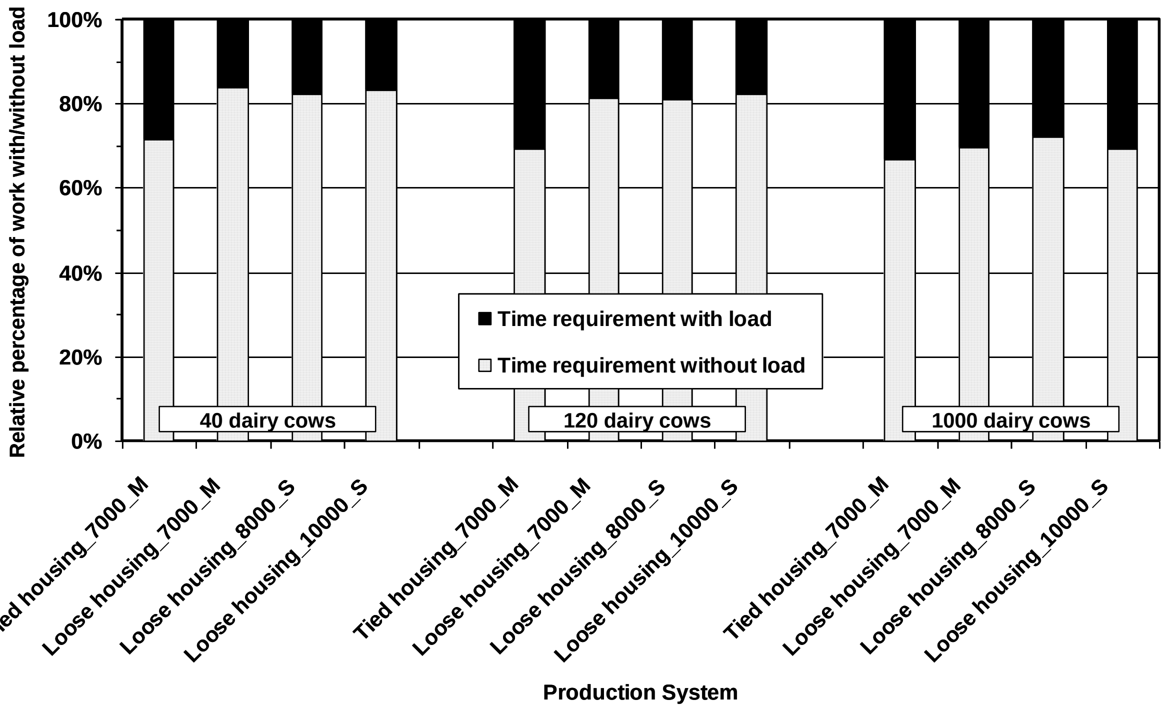

Fig. 3. Average relative workload per kg milk and day for different production systems

A distinct improvement can be achieved in such a system through the deliberate use of tracks or churn-transport devices. In pipeline milking systems, automatic cluster removers and tracks can help make work easier. The load indices of the different milking parlours also varied, since the body postures adopted to perform tasks in the standard processes without the use of technical aids varied to a fairly large extent. Where technical aids (Automatic udder stimulation, automatic cluster removal, milking arm) were adopted wholesale, however, these differences were fairly insignificant. The working-time requirement for all daily tasks (not including management tasks and forage production) rose progressively along with an increase in herd size from 6 MPh for 40 cows to over 50 MPh for 1000 cows per herd and day. At the same time, the percentage of physically strenuous tasks during milking and feeding in a low-mechanisation context rose from 28 to 33%.

With a very good level of mechanisation, the percentage of physically strenuous tasks rose from 16 to 30%. This means that the higher proportion of physically strenuous working time can not be counterbalanced by the working-time degression through increasing herd-size and the technical aids used (diet feeder, milking parlour with milking arm).

The comparison of the different dairy-cow-husbandry production systems highlights the fact that, despite its very good technical configuration, tied housing is the system having the highest physical load. Likewise, in the case of very large herds, year-round feeding of silage and very high milk yields, the highly intensive loose-housing system can be considered relatively unfavourable in terms of physical workload. Medium-sized herds with optimum facilities from a process-engineering perspective (cubicle housing, elevated cubicles, milking parlour with service arm, diet feeder and mechanised refilling of feed) are more favourable in terms of workload.

6. CONCLUSIONS

A precise knowledge of process sequences in milking and feed distribution is of prime importance for determining working-time requirement and modelling dairy-cow husbandry. In addition to this, the growing proportion of management tasks to be accomplished will in future play a significant role.
Unfavourable body postures in combination with masses to be moved manually have a negative impact on work quality. Together with the calculation of working-time-requirement values, a work-budget system incorporating load indices and physically strenuous working times can constitute a helpful instrument for both the qualitative and quantitative evaluation of workload.

7. REFERENCES

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