Work Input for the Production of Organic Eggs in Mobile Chicken Coops

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Abstract: Today's society is increasingly demanding sustainable food production which is livestock-friendly, environmentally sound and user-friendly. To better achieve these goals, organic eggs are sometimes produced in mobile chicken coops. These are adjustable on organic grassland and therefor offer the chicken all-day free space to roam on surfaces with just very few droppings. The impacts of these mobile chicken coops, in particular their equipment, on the work done, have so far not been investigated.

Therefore, the goal of this case study was to record the physical and mental workload of the daily activities in these stables. The data collection took place in an organic farm in Germany, which produced organic eggs with the mobile chicken coops 225 (Hühnermobil 225) and with mobile laying hen coops (Legehennemobil). The daily work in these stables was done by two male and two female study subjects aged 16 to 31 years. The working element method according to AUERNHAMMER (1976) was chosen to categorize the measurement results of the routine work and the HARVARD steptest was applied for the grading of the fitness. For the collection of data, the measuring device Movisens® was used, for the metrological recording of the heart rate and of the Baevsky stress index a qualitative questionnaire for the assessment of the individual stress sensation was developed. The work-related results were evaluated descriptively and analytically, by using the GLM (Generalized Linear Model) and the LR (Logistic Regression).

Among the study subjects, three had a very good and one of them a good level of fitness. In daily routine work, a mean heart rate of 122 bpm was achieved during work in the mobile chicken coops 225 (Hühnermobil 225) and 120 bpm in the mobile laying hen coops (Legehennenmobil) which was above the continuance power rating of 110 bpm. The male subjects were below 103 bpm and the female subjects with 137 bpm above the endurance limit. The heart rate differed significantly according to activity, passage, gender and stable model. Similar results are confirmed by studies on other agricultural enterprises, so that these can be considered valid. A reduction of the physical and of the mental workload, in particular in order to be able to work in a socially sustainable manner under the long-term endurance limit can be achieved through work design (adaptation of other work aides) as well as breaks, slower pace of work and division of labor.

Keywords: *Work input, heart rate, stress, strain;*

I. INTRODUCTION AND OBJECTIVES

The organic egg production is experiencing a steady growth in Austria and Germany. Over the past decade, mobile henhouses, such as the Hühnermobil 225 and Legehennemobil, have been developed. Mobile henhouses are used in free-range productions with a small herd size. Advantages of this system are low construction costs and good hygienic conditions by moving the mobile pen.In mobile chicken coops, farmers can regularly offer hens fresh green areas where they can run and feed. As a result, an accumulation of nutrients and pathogens around the stable area can be reduced and diseases can be better warded off and treated [1].

Fig. 1 Hühnermobil 225 (photograph: Trieb, 2013)

Fig. 2 Legehennenmobil (photograph: Trieb, 2013)

In comparison to the conditions in cage-rearing, the working conditions for the farmer in the mobile chicken coops are more unfavourable.

Disadvantages are caused by higher pollutant concentrations and dust levels due to moist litter and limited transparency for animal care, longer periods for egg collection and physically more demanding work due to adverse loads and ergonomic workplace deficits.

An additional problem is misplaced eggs, which is not present in cages, for example [2].

The extensive mechanisation orless automatization of work processes, as previous studies in livestock farming verify, strengthen moderate to heavy physical work[3]. As a result of high load weights, highly repetitive activities and ergonomically unfavourable postures, the musculoskeletal system of farmers is generally subjected to much stress. This may have a detrimental effect on farmers' health and lead to temporary or permanent incapacity for work[4].

Loss of work due to illness not only causes suffering for those affected, but also economic costs (personnel, material, and possible court costs) and losses (loss of earnings, turnover, image). The aim of occupational health and safety is to avoid the risk of accidents, occupational diseases, work-related illnesses and long-term damage [5].

A study about workload allows an insight into the difficulty of performing specific work processes. Each person performs tasks at different speeds despite the same working conditions. This is due to differences in constitution and skills of people. The differentiation between individuals in the working world is not as significant as in the world of sport; however, a ratio of 1:1.5 to 1:2 can occur[6]. Other differences arise due to gender-specific height and weight of farmers.

For the evaluation of the workload, identification of adverse work loads of activities, the determination of the working time requirement andheart rate can be used. A high heart rate and working time requirement relates to an increased oxygen demand of muscles and increased circulation. The heart rate is influenced by emotional and mental stress and working conditions. It records the total stress of the work and is determined by the R-wave of the electrocardiogram (ECG)[7].

The mental workload describes external factors influencing people mentally such as work tasks and the related requirements, the physical environment and social and organisational factors. These stresses affect the person in form of mental stress. The stress is influenced by the individual characteristics and has the consequence that the same mental stress can have different effects. As a result, desirable effects can occur, affecting the working process positively. Adverse effects have a direct impact on the performance of a person. This leads to fatigue-related conditions such as monotony, reduced vigilance and mental saturation[8].As a result, the psychological stress is predominantly determined by means of a standardized questionnaire [9].

The physical and mental workload usually occurs simultaneously, but can theoretically be divided into sub-loads. The physical workload relates to the stress on the cardiovascular system, including the lungs and breathing, the muscular systems with tendons and ligaments, the skeletal system, including the spinal column, and the sense organs with nerves and glands. By means of the mental workload, the mental-informational and social-emotional stress can be quantified [10]. Commercial semi-automatic blood pressure devices from different manufacturers are available to record the heart rate and thus quantify the load.Literature studies on workload and stress levels in agricultural work are available for animal husbandry [1, 11, 12, 13]. There are no study results on the workload in laying hen husbandry, such as mobile laying hen houses.

Therefore, the aim of this case study was the determination of the physical and mental stress of the daily routine work in mobile chicken coops during the autumn and winter period.

II. MATERIAL AND METHODS

The data collection took place on a farm in Germany, where organic eggs were produced with the Hühnermobil 225 and Legehennemobil von Herrmannsdorf.

The Hühnermobil 225 was designed for 225 laying hens and had an area of 14m². The pen consisted of a lower level, which served as a scratching area, and the upper warm region, where the feeding, watering, perches and nesting boxes were installed.The collection of the eggs took place exclusively from the outside area.The stable model has a manure belt.

The laying hen mobile is a self-construction of the manor Herrmannsdorf and offers space for 192 laying hens. It has a straw-interspersed space that integrates all other areas such as feeding, watering, perches and nests.The subjects entered the stable at ground level. The eggs were taken by entering and collecting from the nests inside the house. When mucking once a month, the entire litter was removed with the feces.

The daily work during the autumn and winter months was done by two male and two female subjects aged between 16 and 31 years. Their parameters are listed in table 1.

Table 1: Specific parameters of the subjects (n=4) (2015)

Subject No.	Gender	Age Years	Height cm	Weight kg	BMI kg/m²
1	Male	25	178	72	22,7
2	Male	19	175	65	21,2
3	female	16	183	60	17,9
4	female	31	173	65	21,7

(BMI=Body-Mass-Index)

None of them smoked.

The examined daily and weekly routines were feeding, monitoring, collecting andpre-sorting eggs. These activities, due to the frequent performance, enabled the comprehensive gender-specific data collection for men and women.

The chickens were fed with a grain mixture from their own yard, which was previously rough-grounded in the yard.

The grain store was located 77 meters from the chicken slot, where the grain was stored in simple big bag sacks and packed in 20 kg sacks after rough-grinding to feed.The feeding took place first of all in the morning, the 20 kg sacks were brought by car or with the wheelbarrow to the stables.The distribution into the feeding troughs was done by hand. In addition to the cereal mix, whole grain was simply scattered in front of the stable.Inspection took place daily in the evening after sunset.

Chickens that were not yet in the stable were caught and all outlet flaps closed.The eggs were collected daily at lunchtime. With a bucket made of straw, the eggs were collected by hand. The nesting flaps were simply opened and the chickens lifted to reach the eggs.The nests were filled with spelt. The filled bucket was brought into the chicken slot and the eggs were sorted and placed in moulded trays, holding 30 eggs, and documented and brought to the cooled egg packing station.

The manure belt was cleaned twice a week. One person drove the farm loader to the barn and put it together with a shovel to the end of the manure belt. The second person brought a shovel and a scraper to the stable.The manure cover was opened and fixed. With a hand crank, the manure belt was turned and the other person removed the chicken manure with the scraper. The manure belt was then rolled back again.

With the laying hen mobile, sprinkling straw once or twice a week was necessary. A wheelbarrow full of straw was brought from the straw storage to the stable. There the straw was distributed by hand throughout the whole stable.

The determination of fitness in the subjects was performed with the Harvard Steptest (4 repetitions per subject), as medical supervision was not possible and the heart rate is influenced by such individual factors as age, gender, ethnicity, physical fitness, illness and medication, external influences, physical activity and mental states [14].

To determine the activity-related workload, heart rate, the routine activities were structured according to Auernhammer's working element method [15].These were subdivided into sub-activities and work elements.

The heart rate measurement, documented over four days per subject, makes it possible to determine a measure of the total load of a person. In this static and dynamic work, mental and emotional stress and environmental factors are taken into account[16]. For recording the heart rate, the ECG and activity sensor of Movisens® was used. This is a psychophysiological ambulatory measurement system, which is attached to the body with a chest strap. The dimensions of the device are 62.3 mm x 38.6 mm x 10.5 mm and it has a weight of 23.2 g. The sensor-amplifier ECG records the raw data of the ECG signal, the 3D acceleration sensor the movements, and the barometric altitude sensor records the air pressure and the temperature for up to several days.

Fig. 2: ECG and activity sensor of Movisens® (photograph: Mayrhofer, 2015)

The fluctuations in heart rhythm were represented by the heart rate variability. This provides information about the stress level of a person. Heart rate variability is referred to as a sensitive and specific indicator which can indicate acceptance of mental strain, decrease in fatigue and increase in relaxation and recreation[17]. The Baevsky stress index is derived from the Russian space medicine and describes the stress state of a person. The human body reacts to different influences by variations in the cardiovascular system. Furthermore, the hormone regulation, energy and metabolic mechanisms are affected. The stress index shows the rhythm stabilisations and disorder reductions in the cardio interval length, which are calculated from the histogram of the heart rhythm distribution curve[18].

For analytical data analysis, the statistical program SAS 9.4® was used. As statistical test methods, the Generalized Linear Model (GLM) and the Logistic Regression (LR) were applied.

III. RESULTS AND DISCUSSIONS

The average working time requirement of the weekly activities was similar in both stables (Figure 3). The slightly higher demand of the laying hen mobile, which was evident in all working elements, can be explained by the fact that there was a smaller number of chickens and consequently the time required or the preparatory and subsequent work subdivisions per hen was higher. In the daily work, feeding in the laying hen mobile by 12.1 MPh was more time-consuming than in the chicken mobile 225. The inspection walk in the evening took a little bit longer, which is due to the larger size of the stable. The working time requirement of the egg collecting process in the Hühnermobil 225 had a lower value, since the opening of the fence and the stable door were not necessary. The slightly higher workload of presorting the eggs in the Legehennenmobil, despite a smaller number of eggs, suggests greater differences in quality. Three of the tested subjects (1, 2, 4) had very good fitness. Subject 3, who was significantly younger and had a higher basal metabolic rate, had good fitness. The body mass index, which was also ideal, was similarly classified.

Despite this good fitness and beneficial body mass index, the mean heart rates in the Hühnermobil 225 and Legehennenmobil were 122 bpm and 120 bpm and exceeded clearly the endurance limit of 110 bpm according to Hartmann et al. 2013 [19].

These threshold exceedances were caused in particular by the activities feeding, egg collection and presorting in both stable types.

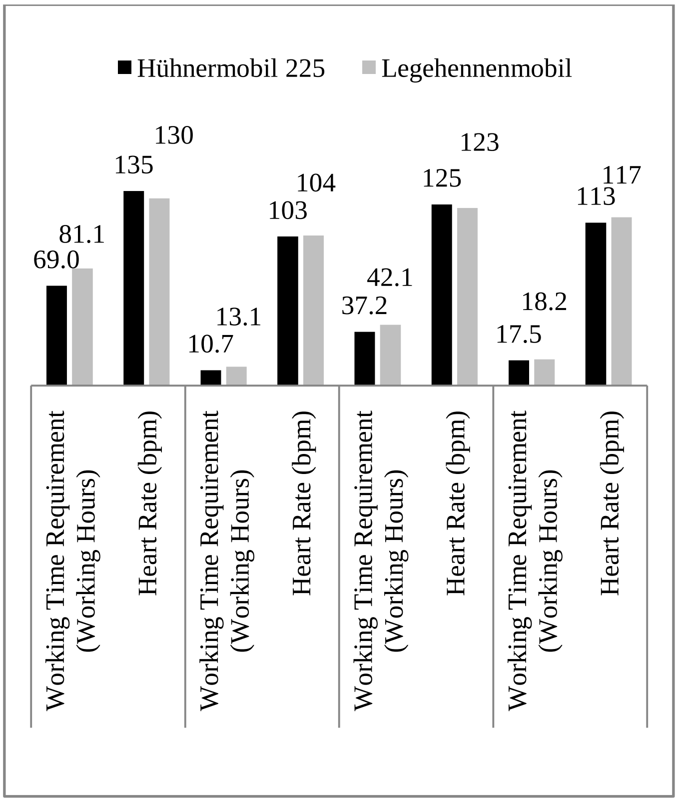

Fig. 3 Working time requirement (in manpower hours (MPh)and mean heart rate (in bpm) of daily routine work according to stable models (n = 8) (2015)

Male subjects in the Hühnermobil 225 and in the laying hen mobile exhibited a lower average heart rate than the female subjects. The male subjects were below 103 bpm and the female subjects with 137 bpm above the endurance limit. The sex and the number of measurement runs were also significantly related to the heart rate of the daily routine. There were significant interdependencies between gender (0.0001 < 0.05 h.s.), the number of measurement runs (0.0001 < 0.05 h.s.) and between the subjects (0.0001 < 0.05 h.s.) and within the sexes (0.0001 < 0.05 h.s., R = 0.99).

The female subjects had a 7.83-fold lower chance than the male subjects to exceed the heart rate limit of the endurance limit. The subjects with a lower level of fitness had a 23.1-fold higher chance to operate on the heart rate limit of the endurance limit than the subjects with better fitness.

The threshold exceedances were due to daily routine work consisting of repetitive hand and arm movements while standing with sometimes heavy load and slow walking in the henhouse. Before and after, the subjects walked the route from the chicken chamber to the stables, which was 152 meters long. Depending on the activity, this route was undertaken with or without load. In the Hühnermobil 225, even more stairs had to be overcome because of the two levels.

Mayrhofer [11] examined in their study the entire milking process and classified it as hard work for men and women, caused by an average heart rate of 106 bpm. Pebrian et al. [12] determined specific work processes in the agricultural sector as heavy work due to an average heart rate of the workers of 133 bpm.

The Baevsky stress index was determined for all activities using the Movisens® measuring device. The metrological recording of data was very patchy. Consequently, the evaluation of the data was performed by subjects. Averages by gender or activities could not be determined, caused by the low volume of data.

Table 2: Average Baevsky stress index in c. u. according to activities and subjects for Hühnermobil 225 and Legehennenmobil

Activities	Hühnermobil 225		Legehennenmobil		
	P1/m	P4/f	P1/m	P2/m	P4/f
Feeding (n=2)	312*	-	406*	-	-
Monitoring (n=2)	51,1	-	85,9	37,3	-
Collecting eggs (n=2)	-	190*	-	-	174*
Pre-sorting eggs (n=2)	54,8	164*	49,5	-	116

(- = no measurement results, normal range: 50-150 c. u., *elevated: 151-500 c. u., **extremely elevated: > 500 c. u., m: male, f: female)

For subject 2 in the Hühnermobil 225 and subject 3 in Legehennenmobil no data were documented. This high measurement error rate was repeated for the activities of feeding and monitoring for subject 4 and collecting eggs for subject 1. The recording of data by the device was insufficient; data quality was not sufficient for their algorithmic calculation. The normal stress index ranged from 50 to 150 c. u. The increased values indicate a limited adaptability of the person. Very high values from 500 c. u. showed exposure to stressors[18]. It could not be determined what kind of stress had occurred in this situation. The huge data gaps were caused by a faulty attachment of the belt, high sweat production or too much upper body movement. After measuring interruptions, the equipment needed around 15 minutes for the calibration in order to continue with the measurement. This does not have a strong effect for measurement periods of 12 or 24 hours; however, for measurement during short successive activities, this time is too long.

Hart (2014)determined the stress index in the milking process and found also a high measurement error rate with the same instrument[20]. Berceli (2009) found similar errors in the measurement of psychological stresswith another measuring instrument, which impacted the quality of data[21].

CONCLUSIONS

The evaluation of the physical stress indicated physical and mental strain, even for most routine activities in mobile coops. An analysis of data on the entire working process (routine and special work) of mobile henhouses should be the next step, including ergonomic evaluation.

The recording of the data sets by sex offered the advantage of a separate assessment of the heart rate and revealed significant gender-specific differences in stress.

For achieving a higher data quality, a larger sample and an analysis of the total work process ergonomically would be helpful.

The wearing of the ECG activity sensor of Movisens® was not seen as a problem by all the subjects. The application initially required a short setting and activation of the device via a laptop. The data storage and analysis with the accompanying software was easily possible. This measuring instrument was developed for the rehabilitation sector and this study examined whether it could be used to monitor work processes in agriculture. An important advantage of this device was the measuring and recording of several parameters during a working process.

The Baevsky stress index, used to determine the mental stress, had detrimental results. To many measurement errors existed, due to the poor sitting of the belt, high welding production or too much movement of the upper body. The algorithmwas based on velocity and neglecting load and must be improved for getting more accurate energy expenditure results for activities that require handling of heavy loads in standing positions, calculated over the heart rate. After measurement interrupts, the device took too much time to calibrate to continue the measurement. Nevertheless, a reduction of the physical and of the mental workload, in particular in order to be able to work in a socially sustainable manner under the long-term endurance limit can be achieved through human work design (ergonomic adaptation of devices) as well as breaks, slower pace of work and division of labour.

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