



Comparative analysis of some investment costs for free rearing of female breeding calves

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Abstract

With varying capacities for dairy cattle breeding farms, this study aims to compare and analyze investment costs for building construction and technological equipment with various methods for free rearing female breeding calves. The ultimate goal is to determine the most economical and practically recommended solutions. This study compares eight different technological variations for freestall rearing of female calves and heifers in farms with forty, sixty, eighty, or one hundred cows. Four of these variations involve buildings with group cubicles on a sloping floor, designed for calves between three and eighteen months old, and four of these variations involve buildings with group cubicles on straw bedding, designed for heifers. Compared to buildings with group cubicles on straw bedding, the variants with a sloping floor for calves and a butterfly landing for heifers are more cost-effective in terms of relative construction costs of the load bearing and fencing structures and total construction costs, while the floor profile variants are more capital-intensive. This is true even though the farm capacity remains the same. The relative construction cost of the technological profile drops from 299 to 203 BGN/st.pl. (up to 47.3%), the relative construction cost of the load bearing and fencing structures drops from 1388 to 832 BGN/st.pl. (up to 66.8%), and the relative total construction cost drops from 1650 BGN/st.pl. to 1080 BGN/st.pl. (up to 52.8%) when the farm capacity is increased from 40 to 100 cows. The most cost-effective option, according to relative construction costs of the buildings' load-bearing and fencing structures (up to 66.7 percent) and total construction costs (up to 52.8 percent), is the one with group cubicles on a sloping floor for calves and Butterfly landing for heifers on a farm that can accommodate 100 cows. Based on the relative construction cost of the floor profile, the version with group cubicles on straw bedding on a farm with a capacity for 100 cows is up to 47.3% more inexpensive than the other options.

Keywords: buildings, female calves, heifers, technological floor profile, load bearing and fencing structures, technical and economic parameters

Introduction

Female breeding calves are often raised without confinement on contemporary dairy farms. Group cubicles are often used for calves under 12 months old, whereas individual cubicles are mostly used for pregnant heifers. According to Dinev *et al.* (1992), Graves *et al.* (2007), Margerison and Downey (2005), and other sources, the best procedures for raising calves include group cubicles on a sloping floor or with thick, non-changeable bedding, as well as butterfly landings for growing heifers. Research on built-up areas, building expenses, and investments in structures for female calves and heifers is scarce in the literature. Buildings with a closed reproductive cycle, in which females and males are reared together, are the primary focus of the reference materials for cow-only facilities (Dimova, 2003; Dinev, 2007; Canada Plan Service, 2006; Holmes *et al.*, 2005; Farm and Rural Buildings Pocketbook, 1991; Pereira, *et al.*, 2003; Wohlfart *et al.*, 2000).

sum needed to create the buildings' technology floor plans using concrete and steel (Dimova and Dinev, 2008). Although research on the impact of technological parameters on these factors has been conducted (Dimova et al., 2010), no study has compared different technological variants or conducted a technical and economic evaluation using the relative construction costs of the technological floor profile, load bearing and fencing structures, or total construction cost as criteria. The current research aims to determine the most cost-effective and practically viable options for dairy cattle breeding farms of varying capacities by comparing and analyzing the investment costs of building construction and technological equipment with various methods for free rearing of female breeding calves.

Material and methods

exclusive confinement for heifers throughout pregnancy (Dimova, 2009; LSU Ag Center, 2005). This research aims to examine eight distinct technical and technological On farms in Bulgaria, there are 40, 60, 80 cubicles with a sloping floor or thick straw bedding, and 100 cows. The authors have developed technical and economic solutions for free rearing of female calves in group breeding animals from 3 to 27 months of age. Out of them, four have undergone partial research on butterfly landings with group heifers in buildings. The authors observed that there are correlations between the methods of raising young breeding heifers (A variants, Figure 1) and four animals in farms with 40 to 100 dairy cows, as well as the capacity and some variations for buildings with group cubicles on straw bedding for calves from 3 to 18 months of age.

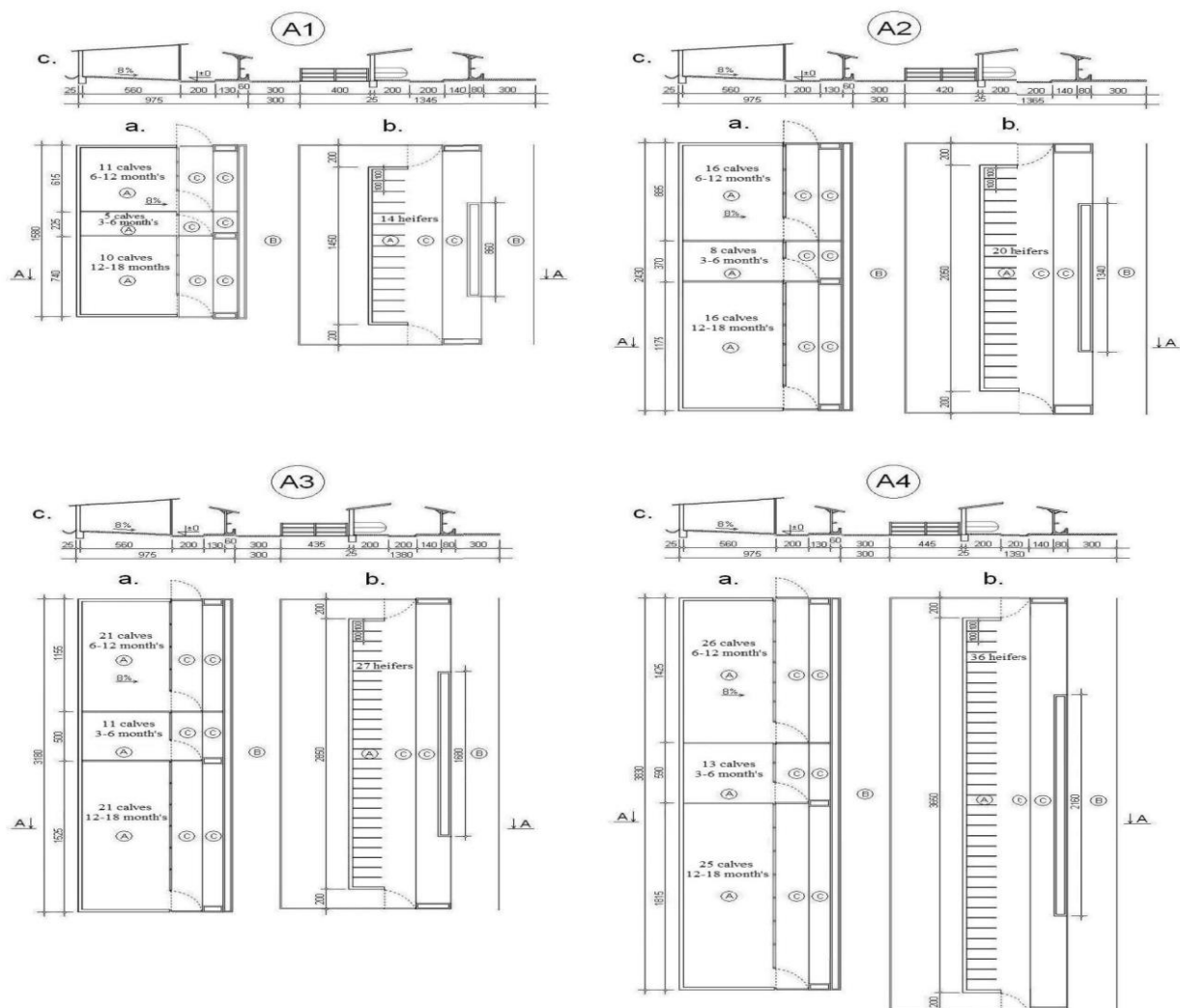




Figure 1. Variants (A) of rearing of female calves and heifers in farms with capacity; A1 - 40 cows, A2 - 60 cows, A3 - 80 cows, A4 - 100 cows, a. building with sloping floor for 3-18 month's calves, b. one-line covered landing type "Butterfly" for heifers, c. transversal section, A - zone for rest, B - zone forage allocation, C - zone for movement

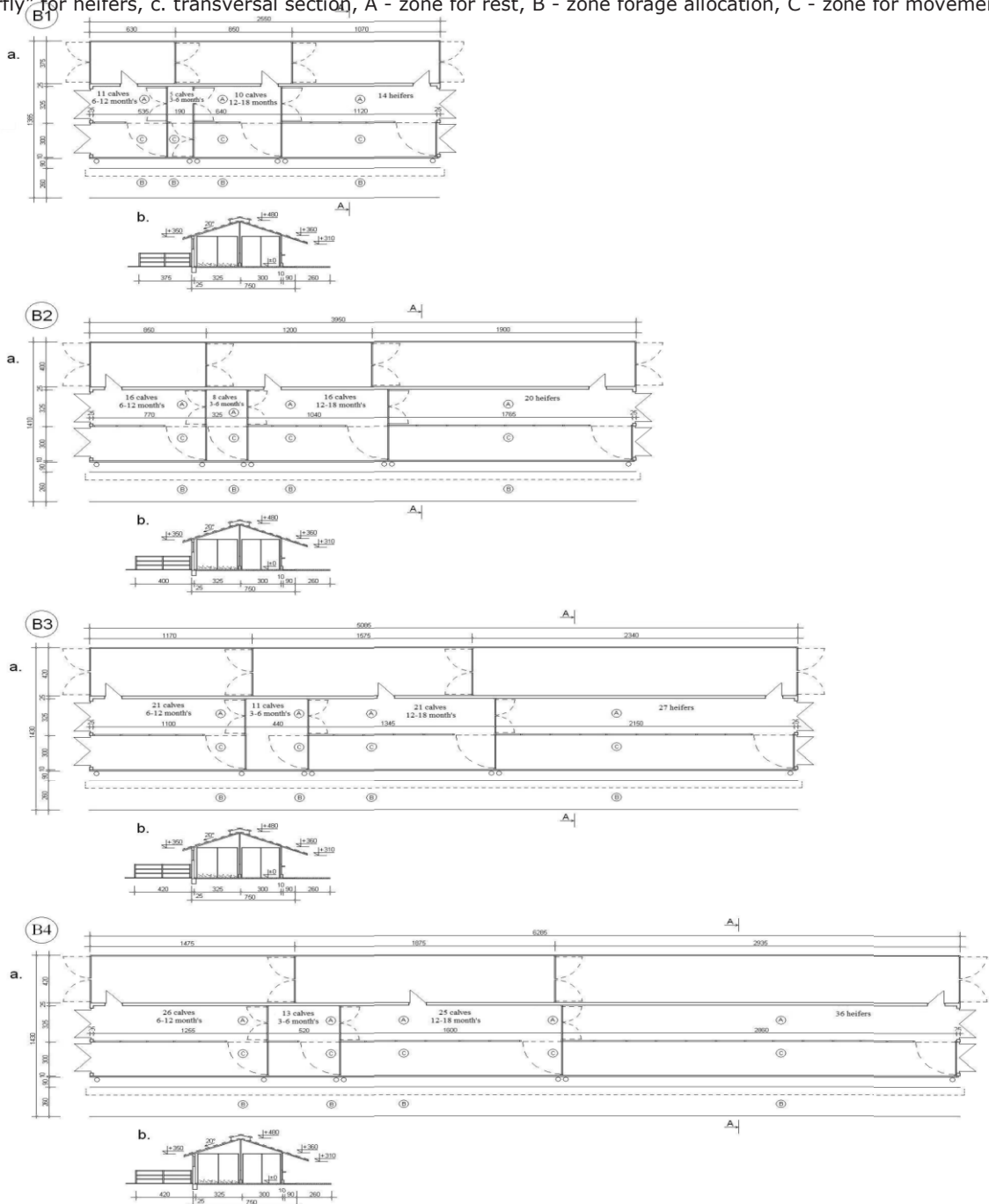


Figure 2. Variants (B) of buildings for rearing over straw bedding of female calves and heifers in farms with capacity B1 - 40 cows, B2 - 60 cows, B3 - 80 cows, B4 - 100 cows, a. plan, b. transversal section, A - zone for rest, B - zone for forage allocation, C- zone for movement

created while subjected to the same initial constraints: the bucket of a bulldozer has been modified. Steel load bearing structures, which are lightweight, are used by the buildings. Open to the south construction expenses for technical floor plans. Brick masonry characterizes the walls; variation A includes solid-walled houses and paddocks; variant B includes load-bearing and fencing structures with longitudinal walls that open along the lower horizontal axis and have windows along the northern side. Structures A structures and the overall price tag for the many varieties. Different variations can be identified by their flat roofs or non-symmetrical gable ends. Typical farm buildings and facilities include cow houses, residential and technical buildings, and material storage facilities. Roofs with ventilation slits covered with polycarbonate transparent material are also included in these variants. We increased the eave of the equipment to 180 cm to cover the fodder alley from rain. This will allow us to store hay, straw, silage, and concentrated latter from the south. This research does not include any variations related to feed, etc. This building's roof is made of sandwich panels constructed from Plasticized LT sheets and polyurethane heat insulation have been used to define built-up zones and paddocks. arbitrary partitioned into regions for relaxation (A), food provision (B), and physical activity The animals have been categorized according to their age: the structural element zone includes the periods from 3 to 6, 6 to 12, and 12 to 18 months, as well as the periods for calves (C), heifers (18 to 27 months), and the region inhabited by walls and load bearing columns. Figures 1 and 2 show the results for all possible group building sizes. In order to lay the technical groundwork Concrete floors have been installed in all zones, ensuring that all cows are fertile and that all profiles are culled at the same rate. The calves have been placed on a thick layer of 10 cm clay, and in the areas designated for the remaining heifers, a soft clay floor is used (Technological standards, 1982).intended to accommodate a concrete strip of 80 cm under the knees while laying down.

In order for the number of stock locations to match up with For the purpose of strengthening the quantity of animals housed in the structure, the steel is further separated into reinforcement. From the time they are three floors old until they reach the age of eighteen months, the calves are housed in communal cubicles that have doors, feeding lanes limiting fixers, and fencing around the perimeter.

2.5 m²/capita from 3 to 6 months, 4.0 m²/capita from 12 to 18 months, and 5.0 m²/capita from 12 to 24 months, respectively. According to Regulation No. 44/20 (2006), heifers are housed in isolated 100 cm x 200 cm x 1 line covered Butterfly landings (variants A) or in group cubicles with a minimum size of 5.0 m²/capita (variants B) on straw bedding. The variations in each rearing technique have all been subjected to the same requirements. An exterior manure lane 200 cm wide is created in version A right adjacent to the calf barn. The dung slides towards the alley when the calves go through the group cubicles due to the floor's considerable slope (8%). According to the technical specifications from 1982, there is a 300-meter-wide feeding alley next to a 130-meter-wide feeding platform, a 60-meter-wide manger, and a cover over all of it. The heifer sector's feeding platform is 140 cm wide, while the manger's is 80 cm. On the platform, you'll find water troughs for one or two groups of animals, and around the edge of the platform, you'll see a tube neck restrictor fixer. Heifers are to be exercised in an unpaved paddock to the north of the Butterfly landing, and all cattle types are now required to have concrete flooring in their exercise paddocks. All the animals in the B versions are raised in the same building. A system of tube doors is used to split the group cubicles, and they are only opened while cleaning is underway. With thick straw bedding for relaxation, manure lane for mobility, and manger alley beneath the eave for feeding—each cubicle is designed in a certain way. According to Graves et al. (2007), the following dimensions have been established: 300 cm for the manure alley, 350 cm for the manger alley, and 325 cm for the rest zone. A tube neck limiting fixer and a 20 cm high wooden board are placed between the manger alley and the manure alley. A 90 cm broad terracotta tile strip may be seen on the feeding alley right close to the plank. Separate watering stations are set up around the edges of the cubicles. All of the cattle types have access



to unpaved pastures where they may run and play, with the exception of the smallest calves (those between three and six months old). The straw bedding is cleaned twice or three times a year, the paddocks once every two to three months, and the manure alley once a month. grassy fields, etc. At the regulated front, variations have been created for rated (dosed) feeding for heifers (60 cm), calves (3 to 6 months; 40 cm), and calves (6 to 12 months; 45 cm) (Regulation No. 44/20, 2006; Technological standards, 1982).

Building built-up area, relative costs of basic construction materials (concrete, reinforcement, and shaped steel), relative costs of construction and erection works for building the technological floor profile, relative costs of construction and erection works for building the load bearing and fencing structures of buildings, and relative total construction cost are the parameters that are used to compare and analyze the variants. The realistically recommendable variations with varying farm capacities are identified by calculating the percentage correlations (%) between the investment cost parameters of each variant and the corresponding characteristics of the most cost-effective technical and technological solution. This study's output data is based on the authors' earlier work, which incorporated their findings about some technical and economic criteria for variants (Dimova and Dinev, 2008). All earthworks (excavations, backfills, etc.), as well as all other construction and erection works (bedding rubble layer, formwork, watertight cement covering, transportation costs, etc.), other than those listed in the relative cost of materials, have been factored into the floor profile construction cost. The construction cost was determined using the pricing (not including VAT) of building and erection works as of May 2010. The approach of comparative analysis is used in the research. Per stock place (st.pl.), which is one cow location on the farm, the relative values of the parameters have been established. Tables illustrate the outcomes of the comparison and assessment, while graphics indicate the relative overall construction value.

Results and discussion

corresponding cell, and then they are let go. Feeding the feed using mobile equipment is done for all types (A and B). You can see the technical and mechanical details of the mixing trailer (as well as the results of the machine's addition of straw to the resting area) in Table 1. As the capacity of the farm increases, it is clear that their total bedding dispersal and manure alley cleaning by tractor with values rise. With the relative accumulation

The most cost-effective combination of area and reinforcing steel and concrete ranges from 42.6% for A4 (0.87 m³/st.pl.) to 52.5% for A2. These structures have group cubicles on thick straw bedding (B variations), with the highest relative concrete cost of 0.93 m³/st.pl. Group cubicles on a sloping floor for calves aged 3 - 18 months and A variants are much more cost-effective as compared to structures with reinforced steel versions. Butterfly landing for heifers (A variations) is 6.7% greater with B4, which has the lowest cost (2.97 kg/st.pl.). On the farm, the B1 variant has a minimum relative built-up cost of 3.17 kg/st.pl. and an area ranging from 2.1 to 2.8 m²/st.pl. It is 2.4% more expensive than the A4 variant (6.32 kg/st.pl.) and significantly less metal than the A3 variant (6.42 m²/st.pl.) with a capacity of 80 cows, up to the consumable A1 (8.38 kg/st.pl.) in terms of metal consumption. How much it costs compared to

46.3%, with a maximum relative built-up area of 9.17 m²/st.pl., instead of A2 at 60 cows. Table 1 shows that the floor profile's concrete cost is directly proportional to its built-up area, as expected given the manner of construction (flooring 10 cm thick). The relative cost of concrete in variations' is seldom affected by the capacity. The costs for B1, B2 and B4 are 0.61 m³/st.pl., and the difference between them

and B3 (0.62 m³/st.pl.) is a little 1.6%. When comparing variations A to the most cost-effective ones, the disparity

shaped steel depends on the length of the building, as a major share in the total cost falls on the technological bafflers and doors in manure alley. Therefore, in buildings with less length higher values of this parameter are recorded. Considerably greater are costs to heifers in variants A, where except for intercubicle dividers a steel for fences of the yards is necessary. The least relative share of shaped steel has been noted for variant A4 (30,89 kg/st.pl.), followed by B4 (31,23 kg/st.pl.) with difference of 1,1%. Between A4 and B1, which

Table 1. Technical and technological parameters of the technological profile of the floor in buildings for free rearing of female calves and heifers *

Variant	Farm capacity, No. of cows	Total built-up area, m ²	Relative built-up area, m ² /stock place	Total concrete consumption, m ³	Relative concrete consumption, m ³ /stock place	Total consumption of reinforced steel, kg	Relative consumption of reinforced steel, kg/stock place	Total consumption of shaped steel, kg	Relative consumption of shaped steel, kg/stock place
A. Variants with group cubicles over sloping floor for calves and one-line covered landing type "Butterfly" for heifers									
A1	40	395.5	8.99	36.8	0.92	335.1	8.38	1688.0	42.20
A2	60	550.0	9.17	55.9	0.93	445.5	7.43	2143.6	35.72
A3	80	706.7	8.83	71.2	0.89	535.3	6.69	2567.4	32.09
A4	100	862.1	8.62	87.1	0.87	631.7	6.32	3089.6	30.89
B. Variants of buildings with group cubicles over bed of straw for calves and heifers									
B1	40	249.5	6.24	24.3	0.61	151.3	3.78	1884.5	47.11
B2	60	401.7	6.70	36.9	0.61	210.4	3.51	2372.6	39.54
B3	80	513.5	6.42	50.0	0.62	253.8	3.17	2675.5	33.44
B4	100	626.5	6.27	61.0	0.61	296.7	2.97	3122.8	31.23

* Data in the table are taken from a previous study of the authors (Dimova V and Dinev D, 2008. Interdependences between some of technological and technical and economic parameters in buildings for female breeding calves and heifers. International scientific conference "Bulgarian science and European research space", Stara Zagora, ISBN 978-954-93-2944-5, (5-6 June 2008), (Bg).

out of all the variations that were tested, it has the highest cost at 47.11 kg/st.pl. The value difference between variants A and B1 ranges up to 52.5%. From 45.0% at A4 (87 BGN/st.pl.) to 52.5% at A2 (93 BGN/st.pl.), A3 has acceptable characteristics (32,09). The cost is 3.9% more than €4. bolstering the floor's technical profile in variations of around four The technical floor plan for the various versions is provided in Table 2, together with the construction values (investments) ranging from 5 BGN/st.pl. (for B1 and B2) to 3 BGN/st.pl. (for B3 and B4). With a difference of 25%, it is clear that the relative values of the alternative construction are bigger with A4 (8 BGN/st.pl.) and A1 (11 BGN/st.pl.), respectively, while for variations A values are 2 to 2.8 times visible. Shaped steel necessitates minimal expenditures with variation A4 (112 criteria for cost of materials), and erection works follow suit in terms of changing values. For instance, the cost of concrete works is BGN/st.pl., which is 1.9% lower than with B4 (114 BGN/st.pl.) and 4.5 times lower in variant B1 (60 BGN/st.pl.). This represents a minimum difference of 53.6% compared to the other variants, which range from A3 - 117 BGN/st.pl., 1,7% to B2 and B4 (61 BGN/st.pl.), and 3.3% to B3 (62 BGN/st.pl.), and 172 BGN/st.pl., respectively. According to the relative cost of

When compared to A variants, B variants (and BGN/st.pl.) are more cost-effective. For B variants with a capacity of 100 cows, the most cost-effective option is farm B4 (24 BGN/st.pl.). This variant is 29,1%



cheaper than 79.2% (than B1, B3 - by 25 BGN/st.pl. and A1, A2 - by 43 BGN/st.pl.), B1 (262 BGN/st.pl.), and the remaining variants (4.9) are 49% cheaper than B3 - 213 respectively. Table 2's data reveals that out of all the A variations, 47.3% (more than A1) had the highest BGN/st.pl. levels. From a total relative value of the technological floor profile, variants B are more economical than variants A by 14.1% with a capacity of A4 (248 BGN/st.pl.), and by 20,6% more economical than A1 (299 40 cows; 262 BGN/st.pl. for A1 compared to 299 BGN/st.pl. for B1), all else being equal.

The construction and BGN/st.pl. (B1) to 302 BGN/st.pl. (B4) may be found in Table 3, together with their relative and total values. Based on that parameter, A variants' erection works for load bearing and fencing structures are significantly less valuable than B variants. The difference between the two variants is demonstrated by the buildings, which include work on paddocks for exercise and feeding of animals. A total of 63.2% is the relative structure value. Both the relative values for roofing and the declines with increase of capacity from 40 to 100 cows show similar connections amongst the variations. A4 is less expensive than the other A variants and B variants. Based on that metric, it is more cost-effective by 2.8 to 6.0 percent compared to the variants with group cubicles on a sloping floor (A3 - 221 BGN/st.pl. and A2 - 228 BGN/st.pl., for calves and heifers, respectively), and by 1.5 to 5.3 percent compared to the B variants (than Butterfly landings for heifers, since for the variants with group B3 - 404 BGN/st.pl. and B2 - 419 BGN/st.pl., respectively). investment in fence constructions using cubicles with straw matting Particularly for roofs, the overall relative construction value of load bearing and increases dramatically. When the farm capacity increases from 40 to 100 cows, the fence structures for female calves and heifers cost 398 BGN/st.pl., which is 1.85 times higher than the cost for A4 (215 BGN/st.pl.).for A variants up to 15.4% and for B variants up to 18.1%. One of the The relative values of the load economics are A4 (832 BGN/st.pl.), which differs from the nest bearing structures in variations A by 4.7%; from 496 BGN/st.pl. to 871 BGN/st.pl., up 41.2% from the most economical in B (for A1) to 432 BGN/st.pl. (for A4) as a result of raising the farm capacity. Among the B variations, variant 4 has the lowest cost at 1175 BGN/st.pl., which is 66.8% lower than the most costly version, variant 3, which comes in at 466 BGN/st.pl., and differs from the other possibilities starting with variant 1, which costs 1388 BGN/st.pl. On the same farm, the percentages range from 1.9% (in B4 - 475 BGN/st.pl.) to 6.4% (in B1 - 496 BGN/st.pl.). The capacity disparities between variants A and B, as well as the A1 and B1 variations, ranging from 38.1% for versions B1 to 1203 for variants A3, and the most cost-effective form is A4, with a capacity of 80 cows and an investment cost of 871 BGN/st.pl. With a capacity of forty cows, the BGN/st.pl. ranges from 43.6 to 44.6 percent. The most minor discrepancies, measuring 5.6 and 7.9% respectively, are associated with A3 (456 BGN/st.pl.) and 960BGN/st.pl. for A1, in contrast to 1388 BGN/st.pl. for B1.

Conclusions

Table 4 and Figure 3 show the different building capacity versions with the same investment expenses for construction and technical equipment, including yards for walk. Buildings with group cubicles on bedding (B variants) are more economical than those with sloping floors for calves and with butterfly landings for heifers, according to the table data, when all costs for load bearing and straw bedding are calculated using the studied parameters: thru connected

The cost of building load bearing and fencing structures with sloping floors and butterfly landings (A variants) ranges from 25,6% to 38.1% to 44.6%, when considering the relative total construction value, which ranges from 25,6% to 31,1% on an 80-cow farm. In comparison to the construction variations for cows (1259 BGN/st.pl. for A1 vs 1650 BGN/st.pl. for B1), the variants for farms with group cubicles (1,416 BGN/st.pl. for B3) result in a 31.1% reduction in costs when using straw bedding. According to the relative construction cost of the floor profile, the most economical option for calves and butterflies

in group cubicles on a sloping floor is A4 (1080 BGN/st.pl.). Landing for heifers has a higher cost, ranging from 14.1 to 22.2 percent, compared to the other A variants. By expanding the farm capacity from 40 to 100 cows, the B versions saw a decrease of 26.6 to 31.1 percent, while the C variants saw a decrease of 1.4 to 1,378 BGN/st.pl. The relative cost of raising female breeding calves in raised stalls on a sloping floor with a butterfly landing can drop as much as 52.8 percent, from 1650 BGN/st.pl. (variant B1) to 1080 BGN/st.pl. (variant B2), when the farm capacity is increased from 40 to 100 parameters. 1700

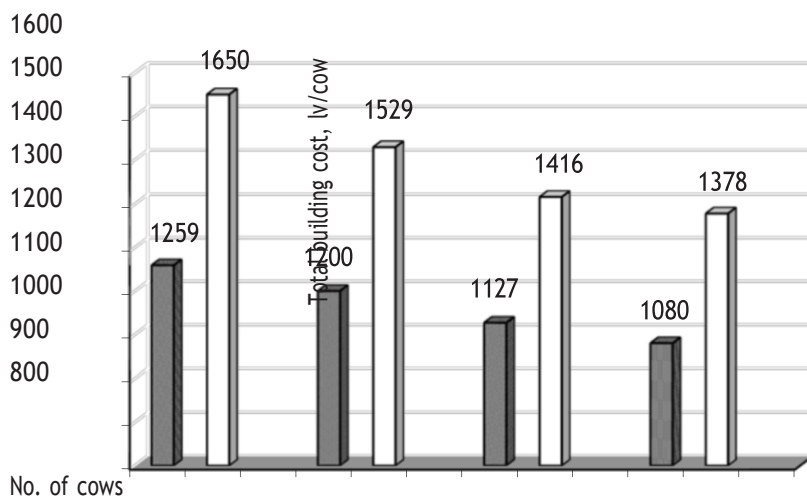


Figure 3. Building cost (investments) for constructing buildings for free rearing of female breeding calves:
 A - variants of buildings with group cubicles on a sloping floor – for calves from 3 to 18 months of age and Butterfly landings – for heifers; B - variants for buildings with group cubicles on a straw bedding for calves and heifers

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When comparing the relative construction values of the load bearing and fence structures, we find that they drop from 1,388 to 832 BGN/st.pl., or 47.3%. Plan Service of Canada, 2006. Cattle from the CPS 2000 Series for Dairy Production. The proportional total construction cost - Cattle Housing and Equipment Leaflet (Metric and Imperial) and dairy BGN/st.pl. (up to 66.8%). a decrease of up to 52.8 percent from 1650 BGN/st.pl. to 1080 BGN/st.pl. The Ministry of Agriculture, Food, and Rural Affairs in Ontario. The variation with sloping floors and group cubicles for calves and heifers (18 animals) <http://www.cps.gov.on.ca/english/dc2000/dc2000.htm>

with a 100-cow herd that uses butterfly landing for its heifers (December 2006) is the best value. Less parameter values are needed for it. In comparison to the other versions, Deenichina G, Bozhkov Y, Pehlivanova S, Georgieva E, and Lazarov found: according to during the relevant building phase (H & Hristova, 2010). Construction cost reference book for load bearing and fence structures, 1, Sofia, Daniel SG outside of normal business hours. As a percentage of the entire building cost, (Bg) might reach 66.7 percent. In 2003, Dimova V. Research into the relationships between the basic version and group cubicles on straw bedding on a farm with a capacity of 100 cows shows that, compared to other variants, this one is up to 47.3% more inexpensive for small dairy farms. Based on the relative building costs of the floor profile, this is the PhD thesis from the Agricultural Institute. The straw-based group cubicle variation is the least desirable option in Stara Zagora (Bg). By Dimova and Dinev (2008). Some of the bedding on a farm that can accommodate forty cows is dependent on others. construction-related technical, economic, and technological factors

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