# Body weight of Holstein Friesian cows

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CVB Documentation report nr. 78
November 2022

*for valuable feeding values*

Internet: www.cvbdiervoeding.nl

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CVB is an activity of the Foundation CVB

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Wageningen Livestock Research (WLR) and

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## Preface

Current CVB estimates for body weights of Holstein Friesian dairy cows are based on datasets used in CVB Documentation report nr. 51 (Voeropnamemodel Melkvee, 2007) and CVB Documentation report nr. 27 (Voeding van drachtige koeien in de droogstand, 2000). It is important to know the actual body weight of the Holstein Friesian cow in order to accurately estimate energy requirements and feed intake levels of dairy cows on commercial dairy farms. There are indications that the average adult body weight of 650 kg used by CVB may be an underestimation of the true body weight of the current adult Holstein Friesian cow in the Netherlands and Belgium. Therefore this study was set up in order to update the body weight of Holstein Friesian cows. We wish to thank the people of CRV, ILVO, Trouw Nutrition, SFR and the Adaptation Physiology group of WUR for providing us with valuable body weight data of Holstein Friesian cows and for their input on the contents of this report. We would also like to thank Ariette van Knegsel for her advice on choosing the best statistical model for evaluating the data. This project was furthermore guided and assessed by the Technical Committee of CVB and the Ad hoc group ‘Actualisatie VEM-systeem’.

Wageningen, November 2022
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## Contents

# 1. Introduction

Current CVB estimates for body weight (BW; kg) of Holstein Friesian dairy cows are based on a dataset of 17.771 week average observations from 726 individual cows derived from 27 feeding experiments (see CVB Documentation report nr. 51; Voeropnamemodel Melkvee, 2007). The average BW of this dataset was 611 kg, with an average parity of 2.9, 85 days in lactation, 17 days pregnancy, 21.2 kg dry matter intake per day, and 33.1 kg milk production per day. Furthermore, CVB BW assumptions for first parity and second parity cows of 540 and 595 kg, respectively, are based on 906 observations for first parity cows and 735 observations for second parity cows. These BW were measured within 2 weeks after calving in the period 1995 – 1999 (see CVB Documentation report nr. 27; Voeding van drachtige koeien in de droogstand, 2000). Furthermore, for third and higher parity lactation cows BW measured within 2 weeks after calving was on average 654 kg and was based on 1,182 observations. In the CVB Documentation report nr. 27 the average BW of all cows (n=2,823) was 601 kg. It is important to know the actual body weight of the Holstein Friesian cows in order to accurately estimate energy requirements and feed intake levels of dairy cows on commercial dairy farms. A correct estimation of feed intake is also required for correctly estimating N and P excretion in feces. The “Kringloopwijzer” is a modelling instrument used in the Netherlands to monitor N and P excretion on Dutch dairy farms. This “Kringloopwijzer” assumes an adult BW of 650 kg (Kringloopwijzer, 2021). This adult BW of 650 kg is based on the CVB Documentation report nr. 51; Voeropnamemodel Melkvee, 2007 and likely also on the results published in CVB Documentation report nr. 27; Voeding van drachtige koeien in de droogstand, 2000. There are indications that this average BW of 650 kg may be an underestimation for the current adult Holstein Friesian cow. This study had the following aims:

1. To determine the current BW of the adult Holstein Friesian cow for the various parities.
2. To estimate BW gain (juvenile growth) for the various parities.
3. To estimate BW loss due to a negative energy balance
4. To estimate the VEM and DVE requirements for BW gain for the various parities.

For this purpose data were collected from 4 research dairy farms and 1 commercial dairy farm in the Netherlands and Belgium during the period 2014 - 2020.

# 2. Materials and Methods

## 2.1 Dataset

From 5 farms cow-week observations were collected, during which BW in almost all cases was measured daily and in all cases directly after milking. These daily BW measurement were afterwards averaged per week. A summary of the dataset is given in Table 1. Average milk production for each of the 5 herds was more than 30 kg/d, thus representing the current dairy farm. The age at first calving for the 5 farms was on average 1.99 years (range: 1.89 – 2.08 years) corresponding to approximately on average 2 years (ranging from 23 – 25 months).

**Table 1.** Summary of the dataset used to determine the average BW of Holstein Friesian cows in the Netherlands and Belgium.

| | Farm | | | | | Total |
|---|---|---|---|---|---|---|
| | 1 | 2* | 3 | 4 | 5 | |
| Period | 2017 - 2020 | 2014 – 2015 | 2017 – 2020 | 2017 - 2020 | 2017 – 2020 | |
| N cows | 352 | 128 | 220 | 266 | 204 | 1,170 |
| N observations | 25094 | 5267 | 6011 | 5643 | 10694 | 52,709 |
| % obs 1th parity | 23.3 | 0.0 | 37.1 | 31.7 | 32.4 | 25.3 |
| % obs 2nd parity | 22.4 | 46.4 | 27.0 | 26.1 | 28.4 | 27.0 |
| % obs 3rd parity | 24.1 | 29.4 | 19.0 | 17.4 | 19.3 | 22.3 |
| % obs 4th parity | 18.8 | 11.4 | 11.8 | 11.1 | 11.6 | 15.0 |
| % obs 5th parity | 8.4 | 7.4 | 3.2 | 8.1 | 6.1 | 7.2 |
| % obs 6th parity | 2.6 | 3.0 | 1.6 | 2.6 | 1.2 | 2.2 |
| % obs 7th parity | 0.4 | 2.5 | 0.3 | 1.7 | 0.9 | 0.8 |
| % obs 8th parity | 0.1 | 0.0 | 0.0 | 0.6 | 0.2 | 0.1 |
| % obs 9th parity | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.1 |
| Parity | 2.8±1.39 | 3.0±1.24 | 2.2±1.26 | 2.6±1.63 | 2.4±1.36 | 2.6±1.40 |
| Days in milk | 178±111 | 150±89 | 159±84 | 160±70.2 | 171±111 | 170±103 |
| BW (kg) | 676±74.5 | 690±74.5 | 671±71.1 | 655±70.0 | 676±76.2 | 675±74.5 |

*Data from second farm were coming from several experiments that did not include first parity animals.

## 2.2 Data analysis and statistical analysis

The BW of the cows was analysed on a week-in-lactation (WIL) basis. Analysis of BW on a WIL basis was done in order to determine for each parity the specific week of lactation that cows had recovered from a negative energy balance. The point of recovery was estimated to be the week in which the estimated BW of the cows was similar to the estimated BW of the cows during the first week of lactation.

Juvenile growth for the various parities was determined as the difference in BW between the analysed BW at WIL 1 of the next parity and the analysed BW at WIL 1 of the parity of interest in order to measure the 'true' BW of the cow and avoid issues with respect to BW-changes due to a negative energy balance of fresh cows and increases in BW as a result of pregnancy. As an example; the average growth during the first parity was calculated as BW at WIL 1 of the second lactation minus BW at WIL 1 of the first lactation. Furthermore, growth during the first lactation was determined for low and high BW cows at WIL 1 of the first parity. This was done by selecting the cows for which BW measurements at WIL 1 was measured for both the first and second parity. Then this group of cows was equally divided in a low and a high BW group and juvenile growth was measured for both the low and high BW group as stated above by subtracting the BW at WIL 1 of the first lactation from the BW at WIL 1 of the second lactation.

The BW of the cows for each WIL and for each parity was analysed with the MIXED procedure of SAS 9.4 using a mixed model with WIL and parity included in the model as fixed effects and by nesting WIL in parity (both WIL and parity were included as class variables). Farm was included as a random variable and repeated measurements on cows

were accounted for using the type=AR(1) option in SAS (allowing for the fact that BW measurements close in time to each other have a higher correlation than measurements that are more distant from each other in time). Because of the limited number of observations for parity 6 and higher, these parities were pooled.

For the Dutch model instrument “the Kringloopwijzer” the average BW of the lactating cattle was determined based on the estimated BW in this study and average percentages of parities in the Dutch dairy herd. Data from CRV from the period of 1-9-2019 to 31-8-2020 shows that the parity percentages in the average herd are 29.7, 25.2, 19.3, 13.0 and 12.8% for, respectively, first, second, third, fourth and higher than fourth parities.

Loss of body weight during lactation as a result of a negative energy balance was calculated as the difference between BW at WIL 1 and the minimum measured BW for each individual cow. Then these values were averaged per parity. Next, these calculated average BW-losses were corrected for differences in digesta weight between cows in WIL 1 and cows at the moment of minimum BW (WIL ranging from 6 (1th parity cows) to 12 weeks (($5^{th}$ parity cows) in lactation. For this correction, a formula from the INRA Feeding System for Ruminants (INRA, 2018) was used for predicting the empty BW of lactating cows (based on a meta-analysis of 10 trials and 50 observations) as a function of days in milk for 3 days in milk (WIL 1; for all parities), for 42 days in milk (WIL 6; for parity 1; moment of observed minimum BW), 55 days in milk (WIL 7.9; for parity 2; moment of observed minimum BW), 80 days in milk (WIL 11.4; for parity 3; moment of observed minimum BW), 76 days in milk (WIL 10.8; for parity 4; moment of observed minimum BW), 85 days in milk (WIL 12.1; for parity 5; moment of observed minimum BW), and 78 days in milk (WIL 11.2; for parity >5; moment of observed minimum BW). The INRA formula is as follows:

Empty BW (% of BW) = 82.72 – 3.077 × (1 – exp(-0.048 × days in milk)) (INRA, 2018)

Then the digesta weight for the above mentioned days in milk for the various parities was calculated as:

Digesta weight (kg) = (100 – empty BW (% of BW)) / 100 × BW (kg)

Then the difference in digesta weight between 3 days in milk and the days in milk at which the minimum BW was observed was calculated and this difference was added to the calculated BW-loss to obtain digesta weight corrected BW-loss values.

## 3. Results and Discussion

In Table 2 the estimated BW are given per WIL for parities 1 - 5 and parities greater than 5 combined and in Fig. 1 the same results are shown but then in a graphical way. Results from Table 2 and Fig. 1 clearly show that cows with parity 1 and 2 are still growing and only reach mature BW at parity 4. BW gain per parity, calculated as the difference in BW between WIL 1 of the parity of interest and WIL 1 of the subsequent parity, was 81, 41, 17, 18 and -12 kg for,

respectively, parity 1, 2, 3, 4, and 5. These values not only show that first and second parity cows are growing during lactation, but also show that that at least even third parity cows are growing. This increase in BW for first parity cows of 81 kg is substantially larger than the 55 kg increase assumed by the CVB. Furthermore, the increase in BW for second parity cows of 41 kg is somewhat lower than the 55 kg increase in BW assumed by the CVB. In the CVB system the assumed increase in BW for both parity 1 and 2 cows is 55 kg, the VEM and DVE requirements for growth set for parity 1 cows is twice as high as for parity 2 cows which perfectly agrees with the observation of this study that BW gain for first parity cows is twice as large as BW gain for second parity cows. The average BW of first parity cows in WIL 1 in this study is 572 kg and is 32 kg higher than presently assumed by CVB. The average BW of second parity cows in WIL 1 in this study is 653 kg and is 58 kg higher than presently assumed by CVB. The average BW of third parity cows in WIL 1 in this study is 694 kg and is 44 kg higher than presently assumed by CVB for adult cows. Furthermore, BW of parity 4 and 5 cows in this study at WIL 1 are 711 and 728 kg, respectively, and are, respectively, 61 and 78 kg greater than presently assumed by CVB for adult cows. Clearly, the BW of current HF cows is substantially higher than presently assumed in CVB publications and in the Kringloopwijzer.

**Table 2.** Estimated BW (±SE) for parities 1 – 5 and greater than parity 5 for a complete year.

| Week in lactation | Parity | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | >5 |
| 1 | 572±5.6 | 653±5.6 | 694±5.8 | 711±6.2 | 728±7.3 | 716±9.7 |
| 2 | 564±5.6 | 642±5.6 | 679±5.8 | 695±6.1 | 714±7.2 | 693±9.6 |
| 3 | 562±5.6 | 638±5.6 | 674±5.8 | 689±6.1 | 707±7.2 | 681±9.5 |
| 4 | 562±5.5 | 637±5.6 | 672±5.8 | 684±6.1 | 704±7.2 | 679±9.5 |
| 5 | 564±5.5 | 636±5.6 | 671±5.8 | 683±6.1 | 701±7.2 | 678±9.5 |
| 6 | 565±5.5 | 637±5.6 | 670±5.8 | 682±6.1 | 703±7.1 | 678±9.4 |
| 7 | 569±5.5 | 637±5.5 | 670±5.7 | 685±6.1 | 699±7.1 | 681±9.5 |
| 8 | 571±5.5 | 636±5.5 | 673±5.7 | 687±6.1 | 697±7.1 | 680±9.4 |
| 9 | 573±5.4 | 638±5.5 | 675±5.7 | 689±6.1 | 698±7.1 | 677±9.4 |
| 10 | 577±5.4 | 639±5.5 | 676±5.7 | 689±6.0 | 698±7.1 | 677±9.4 |
| 11 | 580±5.4 | 641±5.5 | 679±5.7 | 689±6.1 | 697±7.1 | 679±9.4 |
| 12 | 584±5.4 | 642±5.5 | 679±5.7 | 690±6.1 | 698±7.2 | 681±9.4 |
| 13 | 588±5.4 | 645±5.5 | 682±5.7 | 693±6.1 | 700±7.2 | 677±9.4 |
| 14 | 591±5.4 | 647±5.5 | 683±5.7 | 693±6.0 | 697±7.2 | 682±9.4 |
| 15 | 593±5.4 | 649±5.5 | 685±5.7 | 692±6.0 | 700±7.2 | 682±9.4 |
| 16 | 597±5.4 | 652±5.5 | 687±5.7 | 695±6.0 | 700±7.1 | 684±9.3 |
| 17 | 601±5.4 | 654±5.5 | 689±5.7 | 696±6.0 | 701±7.1 | 687±9.3 |
| 18 | 605±5.4 | 656±5.5 | 690±5.7 | 695±6.0 | 701±7.1 | 695±9.3 |
| 19 | 607±5.4 | 659±5.5 | 691±5.7 | 696±6.0 | 701±7.1 | 710±9.2 |
| 20 | 610±5.4 | 661±5.5 | 692±5.7 | 698±6.0 | 701±7.1 | 711±9.3 |
| 21 | 611±5.4 | 662±5.5 | 694±5.7 | 697±6.0 | 698±7.1 | 713±9.3 |
| 22 | 612±5.4 | 664±5.5 | 694±5.7 | 699±6.0 | 699±7.1 | 714±9.4 |
| 23 | 614±5.4 | 664±5.5 | 694±5.7 | 697±6.0 | 699±7.1 | 716±9.5 |
| 24 | 616±5.4 | 666±5.5 | 696±5.7 | 700±6.0 | 699±7.1 | 715±9.5 |

**Table 2. Continued.**

| Week in lactation | Parity | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | >5 |
| 25 | 617±5.4 | 669±5.5 | 696±5.7 | 702±6.0 | 698±7.1 | 718±9.6 |
| 26 | 618±5.4 | 670±5.5 | 697±5.7 | 704±6.0 | 697±7.2 | 716±9.6 |
| 27 | 620±5.4 | 671±5.5 | 699±5.7 | 704±6.0 | 696±7.2 | 713±9.7 |
| 28 | 622±5.4 | 672±5.5 | 701±5.7 | 706±6.0 | 698±7.2 | 711±9.8 |
| 29 | 623±5.4 | 676±5.5 | 702±5.7 | 708±6.0 | 697±7.2 | 710±9.9 |
| 30 | 626±5.4 | 678±5.5 | 703±5.7 | 711±6.1 | 697±7.2 | 710±10 |
| 31 | 628±5.4 | 681±5.5 | 705±5.7 | 716±6.1 | 699±7.2 | 709±9.9 |
| 32 | 631±5.4 | 684±5.5 | 707±5.7 | 720±6.1 | 702±7.3 | 711±10 |
| 33 | 632±5.4 | 686±5.5 | 709±5.7 | 722±6.1 | 706±7.3 | 715±10.0 |
| 34 | 635±5.4 | 689±5.5 | 712±5.7 | 723±6.1 | 705±7.3 | 718±10.0 |
| 35 | 636±5.4 | 692±5.5 | 715±5.7 | 726±6.1 | 708±7.4 | 718±10.1 |
| 36 | 638±5.5 | 695±5.5 | 718±5.7 | 729±6.1 | 712±7.4 | 723±10.3 |
| 37 | 643±5.5 | 699±5.6 | 721±5.8 | 729±6.2 | 717±7.5 | 726±10.5 |
| 38 | 646±5.5 | 703±5.6 | 725±5.8 | 732±6.2 | 722±7.5 | 732±10.7 |
| 39 | 650±5.5 | 708±5.6 | 728±5.8 | 736±6.2 | 727±7.6 | 733±11.2 |
| 40 | 653±5.5 | 712±5.6 | 731±5.8 | 741±6.3 | 733±7.7 | 736±11.4 |
| 41 | 655±5.5 | 715±5.6 | 736±5.8 | 743±6.3 | 736±7.8 | 737±11.5 |
| 42 | 658±5.6 | 718±5.7 | 738±5.9 | 747±6.3 | 737±7.9 | 740±11.8 |
| 43 | 661±5.6 | 723±5.7 | 742±5.9 | 749±6.4 | 740±8 | 727±11.8 |
| 44 | 664±5.6 | 727±5.8 | 748±6.0 | 750±6.5 | 736±8.1 | 724±12.5 |
| 45 | 666±5.7 | 729±5.8 | 751±6.1 | 753±6.5 | 738±8.2 | 728±12.9 |
| 46 | 667±5.7 | 733±5.9 | 754±6.1 | 759±6.6 | 741±8.4 | 737±13.2 |
| 47 | 672±5.8 | 736±6.0 | 759±6.2 | 762±6.8 | 747±8.4 | 744±13.4 |
| 48 | 675±5.9 | 738±6.1 | 764±6.3 | 764±6.9 | 752±8.5 | 745±13.9 |
| 49 | 678±6.0 | 740±6.2 | 766±6.4 | 766±7.0 | 752±8.6 | 751±14.4 |
| 50 | 679±6.1 | 741±6.4 | 769±6.5 | 768±7.2 | 753±8.9 | 757±14.7 |
| 51 | 681±6.3 | 743±6.6 | 771±6.6 | 768±7.4 | 751±9.0 | 760±15.0 |
| 52 | 683±6.4 | 750±6.8 | 775±6.8 | 772±7.5 | 753±9.4 | 758±15.4 |
| 53 | 688±8.3 | 752±10.7 | 777±8.9 | 775±16.2 | 770±16.7 | 769±20.8 |

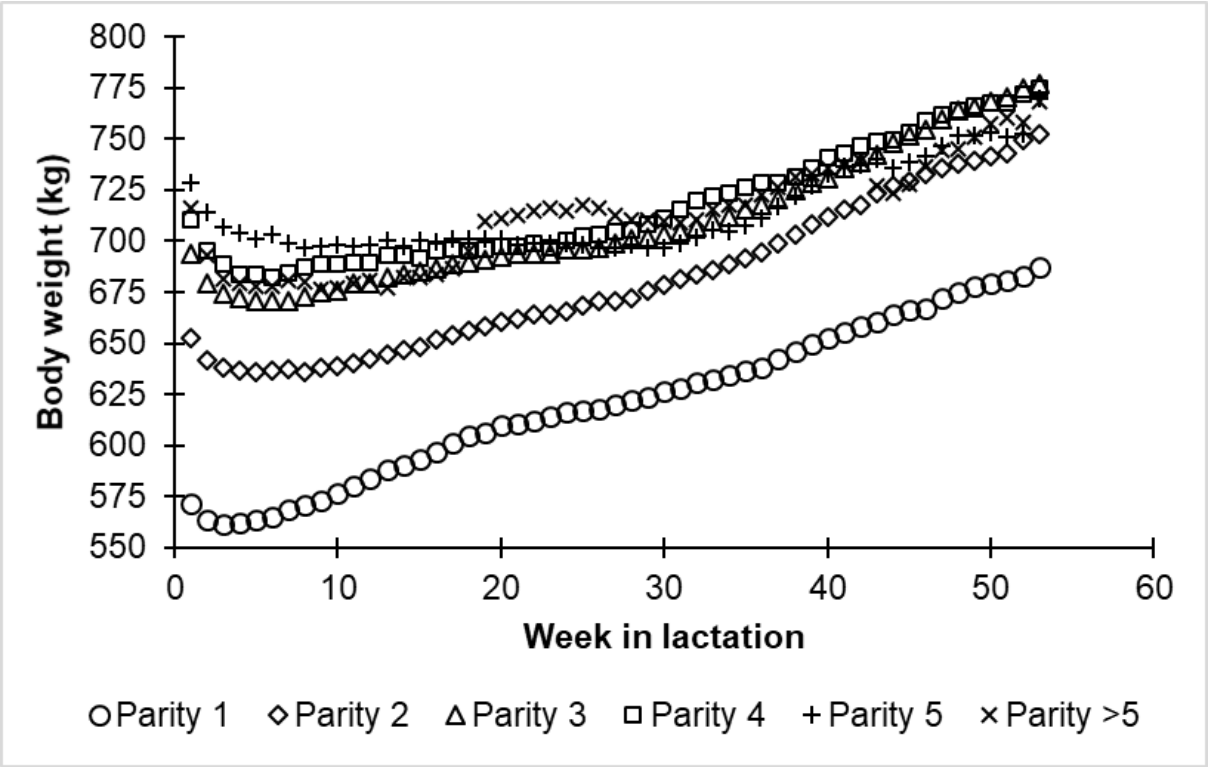


**Figure 1.** Relationship between estimated body weight and week in lactation for cows for parity 1 – 5 and parity >5.

Results in Table 2 also show that BW loss after calving, as measured by the difference in BW at the first week of calving and the lowest BW after calving, is 10, 17, 23, 29, 31 and 39 kg for, respectively parity 1, 2, 3, 4, 5 and >5 and increases as the parity number increases. Furthermore, the WIL at which minimum BW is measured increases at increasing parity being 3, 5, 6, 6, 8 and 9 weeks for, respectively, parity 1, 2, 3, 4, 5 and >5. Results in Table 2 furthermore show that at increasing parity it takes longer for the cow to recover from BW loss due to a negative energy balance. For first parity cows it takes 9 weeks, for second parity cows 17 weeks, for third parity cows 21 weeks, for fourth parity cows 30 weeks, for fifth parity cows 40 weeks, and for higher than fifth parity cows 34 weeks. This calculated recovery period of 40 weeks for fifth parity cows might even be an underestimation as BW gain as a result of pregnancy was not taken into account (based on the study of Putnam and Henderson, 1946, an extra weight due to pregnancy can be expected of around 29 kg at 40 weeks in lactation when assuming a calving interval of 12 months).
The maximum BW loss expressed as a percentage of BW at the first WIL in this study was 1.7, 2.6, 3.3, 4.0, 4.3 and 5.5% for first, second, third, fourth, fifth and >5 parity, respectively. This is substantially less than reported in other studies such as van Straten et al. (2008), Rehak et al. (2012) and Poncheki et al. (2015). Van Straten et al. (2008) observed in Israeli HF cows (average milk production 11,587 – 13,000 kg milk/year) maximum BW loss of 6.5% at 29 days in lactation for first parity cows, and maximum BW loss of 8.5% and 8.4% for second parity and greater parity at 34 and 38 days in lactation, respectively. Rehak et al. (2012) observed for Holstein cows an average maximum BW loss of 7.9%.

Poncheki et al. (2015) observed in Holstein cows maximum BW losses of 8.4, 6.6 and 7.3% for first, second and third parity cows, respectively.
Therefore, as an extra check, for all cows that had BW observations at WIL 1 (n=948 observations from 633 cows; some cows had BW observations for multiple parities), the difference was calculated between BW at WIL 1 and minimum BW. From this analysis it appeared that the average maximum BW loss expressed as a percentage of BW at WIL 1 was 4.3±3.89, 4.2±3.98, 6.3±4.67, 6.8±5.28 and 7.7±4.94 and 7.2±6.29% for, respectively, parity 1, 2, 3, 4, 5 and >5. These values, when converted to absolute BW losses, are 25, 28, 45, 50, 56 and 53 kg for parity 1, 2, 3, 4, 5 and >5, respectively. Furthermore, the lowest BW was observed at 6.0±6.88, 7.9±8.34, 11.4±10.37, 10.8±9.13, 12.1±11.52 and 11.2±12.27 WIL for, respectively, parity 1, 2, 3, 4, 5 and >5. These maximum BW losses are more in line with data from the literature. The high standard deviations with respect to 1) these average maximum percentual BW losses and 2) the average WIL at which maximum BW loss is reached show that there are substantial differences between animals with respect to maximum BW loss and BW loss in time. These large differences between animals may provide an explanation for the fact that model estimates for BW (results presented in Table 2) resulted in lower maximum BW losses. This also indicates that the present design of the model is not suited very well to capture this cow specific BW change in time. It was therefore also analysed if calculating the average BW values for the various parity-WIL combinations would result in average BW values that would result in higher calculated maximum BW loss values but this was not the case (it did not result in higher calculated maximum BW losses compared to model estimates).

Random estimates for farm 1 – 5 were, respectively -7.1±4.21, -0.2±4.99, 10.0±4.53, -8.3±4.42 and 5.7±4.39. These random estimates show that differences in BW between farms were small, the largest difference between the 5 farms was 18.3 kg. Differences in BW between farms may be expected due to differences in BW at first insemination and at calving, due to differences in genetics and due to differences in management. Therefore, it was also tested what the effect of BW at the first WIL of first parity cows was on BW gain during the first lactation. This was done by selecting first all cows on which BW at WIL 1 was measured during both the first and second lactation. This resulted in 69 observations. From these 69 cows also the WIL observations were selected for WIL 1 - 40 of the first lactation and as well for WIL 1 of the second lactation. The average BW at WIL 1 of these 69 cows was 576±41.7 kg and the median weight was 575 kg. Then, these group of 69 cows were divided in a low BW class (BW less than 575 kg; n = 34) and a high BW class (BW equal or higher than 575 kg; n = 35). In Fig. 2 the relationship between WIL and average BW for first parity cows for the low and high BW class is presented. Results in Fig. 2 clearly show that the increase in BW in time is substantially larger for the low BW class than for the high BW class. Results from Fig. 2 furthermore shows that at a WIL of 40 the BW of the high and low BW class are almost equal. Indeed, BW at WIL 1 was 610±23.9 and 540±21.7 kg for, respectively, the high and low BW class cows and BW at WIL 40 was 654±53.8 (n = 27) and 638±50.5 (n = 30) kg for, respectively, the high and low BW class cows. The initial average difference of 70 kg at WIL 1 was reduced to 16 kg at WIL 40.

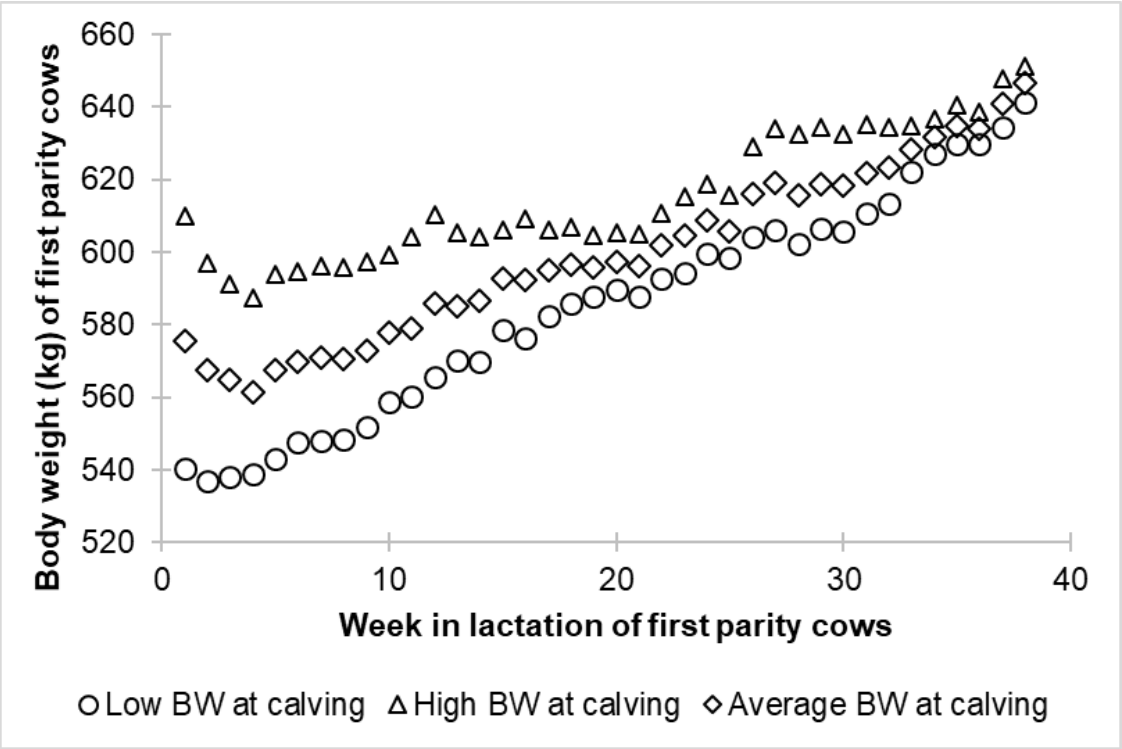


**Figure 2.** Relationship between average body weight and week in lactation of first parity cows divided in cows with a low body weight (BW) at first week after calving (BW = 540±21.7 kg; n = 34) and cows with a high BW at calving (BW = 610±23.9; n = 35).

The results of the comparison between BW at first and second parity between the high and low BW class are presented in Table 3. When comparing the BW between first and second parity of these 69 observations it also becomes clear that much (67%) of the difference in BW at WIL 1 of first parity cows between high and low BW cows (difference of 70 kg) has disappeared at WIL 1 of the second parity (difference of only 23 kg). From this it is concluded that BW gain during the first lactation is dependent on the BW at first calving and that differences in BW at the start of the first calving gradually decrease in time during the first lactation. This information is useful in case BW at first calving deviates from the average BW presented in this study for the calculation of energy allowances for BW gain (see next section on “Proposal for CVB and Kringloopwijzer”.

**Table 3.** Body weight (BW) of high and low class BW cows at week in lactation (WIL) 1 at first and second parity. Only observations were included in which BW of cows was recorded for WIL 1 for both first and second parity.

| | BW (kg) at WIL 1 | | Difference in BW |
|---|---|---|---|
| | Parity 1 | Parity 2 | parity 1 minus parity 2 (kg) |
| High BW (n = 35) | 610±23.9 | 666±49.4 | 56 |
| Low BW (n = 34) | 540±21.7 | 643±46.3 | 103 |
| Average BW (n = 69) | 576±41.7 | 655±49.0 | 79 |
| High BW – Low BW | 70 | 23 | NA |

# 4. Proposal for CVB and Kringloopwijzer

In the CVB Booklet Feeding of Ruminants (2016) the average BW for first, second and third and higher parity cows is assumed to be 540, 595 kg and 650 kg, respectively. However, these weights are based on measurements during the first two weeks of lactation and are therefore an underestimation of the average BW of the first and second parity cows as the increase in BW due to growth is not taken into account. This also means that both first and second parity cows gain 55 kg in BW during lactation, whereas third lactation cows do not gain BW. It is proposed to base the BW of animals on the BW estimated at the first week of lactation. As first, second, and third parity cows are still growing during lactation, it is proposed for these parities to add to the BW estimated at WIL 1 50% of the estimated BW gain during lactation. The BW values as presented in Table 4 are then proposed. The values presented in Table 4 are valid for high producing HF-cows receiving high quality, energy dense, diets and may not reflect average BW, BW-gain, and BW-losses of cows kept under difference conditions such as cows being fed high roughage, low-energy, diets.

**Table 4.** Body weights per parity according to present CVB values and proposed based on the results of this study.

| Parity | Present CVB values | | Estimated BW at WIL 1 (kg) + 0.5 × BW gain during the entire lactation* (kg) | Proposed new CVB values for BW** (kg) | Proposed increase in BW per parity**,*** (kg) | Total BW-loss (BW at WIL 1 minus minimum BW)**** (kg) | Increase in digesta weight**** (kg) | BW-loss corrected for digesta weight***** (kg) | Proposed BW-loss corrected for digesta weight***** (kg) |
|---|---|---|---|---|---|---|---|---|---|
| | BW at WIL 1 and 2 (kg) | BW-gain (kg/lactation) | | | | | | | |
| 1 (Average BW) | 540 | 55 | 572 + 0.5 × 81 = 613 | 615 | 80 | 25 | 8 | 33 | 35 |
| 1 (Low BW) | 540 | 55 | 540 + 0.5 × 103 = 592 | 590 | 105 | | | | |
| 1 (High BW) | 540 | 55 | 610 + 0.5 × 56 = 638 | 640 | 55 | | | | |
| 2 | 595 | 55 | 653 + 0.5 × 41 = 674 | 675 | 40 | 28 | 10 | 38 | 40 |
| 3 | 650 | 0 | 694 + 0.5 × 17 = 703 | 705 | 15 | 45 | 9 | 54 | 55 |
| 4 | 650 | 0 | 711 + 0.5 × 18 = 720 | 720 | 15 | 50 | 8 | 58 | 60 |
| 5 | 650 | 0 | 728 - 0.5 × 12 = 722 | 720 | 0 | 56 | 8 | 64 | 60 |
| >5 | 650 | 0 | 716 | 720 | 0 | 53 | 8 | 61 | 60 |

*BW gain calculated as the difference in BW between BW at WIL (week in lactation) 1 and the BW at WIL 1 of the next lactation. This difference is then multiplied by 0.5 in order to obtain the average BW of the cow during the entire lactation. This will result in an estimation of the energy requirement for maintenance that is on average sufficient for the entire lactation period and dry period. The estimated values for BW at WIL 1, BW-gain and BW-loss for parity 1 (Average BW) and parity 2 - >5 cows are based on the total dataset whereas for the parity 1 (Low BW) and parity 1 (high BW) cows these values are estimated on a subset of the total dataset of cows for which BW was recorded for WIL 1 for both the first and the second parity (n = 69).

**Rounded values.

***The proposed increase in BW due to juvenile growth is calculated as the difference in BW between BW at WIL 1 and the BW at WIL 1 of the next lactation and then this calculated value was rounded.

****The calculated total BW-loss as a result of a negative energy balance in the first few months of lactation.

*****The calculated total BW-loss as a result of a negative energy balance in the first months of lactation was corrected for the effect of an increased digesta weight at the moment of maximum BW loss compared to the digesta weight at WIL 1 (see M&M for a more detailed explanation).

In the CVB Booklet Feeding of Ruminants (2016) also energy and protein requirements are provided for growth, amounting to 660 VEM and 37 g DVE per day for first parity cows and 330 VEM and 19 g DVE per day for second parity cows. It is not exactly clear how these values were calculated. The following calculation rules as described in the CVB Feed Table for beef production and in the calculation of VEM values were used to calculate VEM requirements for growth for the various parities in this study:

- Net Energy requirement growth ($NE_G$; kJ/d) = ((500 + 6 × BW) × 4.184 × BWG) / (1 – BWG × 0.3)
- Dietary metabolizable energy : gross energy ratio × 100 (q) = 63.6
- Conversion efficiency of metabolizable energy into $NE_G$ ($k_f$) = 0.0078 × q + 0.006
- Conversion efficiency of metabolizable energy into milk ($k_l$) = 0.405 + 0.00418 × q
- Metabolic Energy requirement for growth ($ME_G$; kJ/d) = $NE_G$ / $k_f$
- VEM requirement growth (VEM/d) = $ME_G$ × $k_l$ / 7.82

Where BW = body weight (kg), BWG = BW-gain (kg/d);.

For growth, next to VEM, also DVE is required. The DVE requirement for growth is calculated based on CVB documentation report nr. 19:

DVE (g/d) = EA / Ke

Where:
EA = protein deposition (kg/d)
Ke = the conversion efficiency of protein deposition

Ke = calculated as: 0.7862 / (1+EXP(-0.005286 × (BW -417.7)))
EA = 144 × BWG (kg/d) + 8.95 (this equation is based on regressing EA on BWG in the Table presented in Appendix 6 in the CVB documentation report nr. 19).

The calculated VEM and DVE requirements for growth are given in Table 5. The values presented in Table 5 are valid for high producing HF-cows receiving high quality, energy dense, diets and may not reflect average BW-gain and VEM- and DVE-requirements for growth of cows kept under difference conditions such as cows being fed high roughage, low-energy, diets.

**Table 5.** Daily VEM and DVE requirements for body weight grain (BWG) for 1 – 4 parity cows.[1]

| Parity | Increase in BW[2] (kg per lactation) | FPCM[3] (kg/d) | BWG[4] (kg/d) | VEM req. growth[5] (VEM/d) | | | DVE req. growth (g/d) | |
|---|---|---|---|---|---|---|---|---|
| | | | | Calculated | Proposed | Present CVB values | Calculated and proposed | Present CVB values |
| 1 (Av. BW) | 80 | 29 | 0.196 | 624 | 625 | 660 | 64 | 37 |
| 1 (Low BW) | 105 | 29 | 0.257 | 805 | 800 | | 82 | 37 |
| 1 (High BW) | 55 | 30 | 0.135 | 436 | 425 | | 47 | 37 |
| 2 | 40 | 32 | 0.098 | 329 | 325 | 330 | 37 | 19 |
| 3-4 | 15 | 34 | 0.037 | 127 | 125 | 0 | 22 | 0 |

[1]In the calculation of VEM-requirements for growth the calculations are based on an assumed ration with a q-value of 63.6 (average q-value of the climate respiration dataset on which the new VEM-system is based (CVB Documentatierapport nr. 79) and a corresponding $k_f$ value of 0.502 ($k_f$ = conversion efficiency of metabolizable energy into net energy for growth) and $k_l$ value of 0.671 ($k_l$ = conversion efficiency of metabolizable energy into milk).

[2]Calculated as the difference in BW between average BW of parity 2 and parity 1 in the first week of lactation as presented in Table 3.

[3]Fat and protein corrected milk. These values are based on the average milk production values of the dataset used in this study.

[4]A calving interval of 408 is assumed, based on the average calving interval of dairy cows in the Netherlands as reported by CRV (CRV, 2019).

[5]VEM requirements based on the updated VEM-system (CVB Documentatierapport nr. 79; with no negative effect of feed intake level on metabolizable energy content of feedstuffs and multiplying the calculated NE requirement for growth (kJ/d) with a factor of 7.82 in order to express it in VEM units).

The Kringloopwijzer assumes an average BW of 650 kg based on CVB. Based on the average herd composition as given by CRV (see M&M section) and the proposed new CVB values in Table 3 the average BW of the HF cow is on average 675 kg.

## 5. References


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