Integrative predictions of free water intake, urine volume and fecal water excretion in dairy cows under thermoneutral condition

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At a world scale, the concomitant increase of livestock production and risks of global warming will reinforce the issue of the use of water for livestock (Chapagain and Hoekstra, 2003). Even though the requirements for animal watering are small compared to the water requirements for irrigation for feed production, it is difficult to reduce it without directly affecting the integrity of the herds. In temperate climates, concurrences in the uses of water can occur during drought periods and in this context, it will be essential to predict accurately the water requirement of the herds, particularly dairy herds. Moreover, at the farm level, the volume of water excreted by livestock partly determines the size of the manure storage facilities, which can affect the dynamics of land applications. The aim of this work was to establish a set of predictive equations of the main daily water flows at the level of a dairy cow (free water intake, urine and feces excretion), according to the diet characteristics and the animal performance, from a dataset of cows water balances collected during the last 30 years at the experimental farm of INRA at Méjussaume (France).

Materials and methods The dataset used to build predictive equations included 342 individual measurements of daily water balance in dairy cows (free water intake FWI, water ingested with the feed, excreted in urine, in feces, or in milk), collected from 18 energy and N balance conducted between 1983 and 2005. 281 measurements were obtained from lactating cows and 61 from dry cows. Considering the diets offered to the cows, 92 measurements were obtained on diets based on freshly cut grass, 94 measurements on diets based on corn silage based diets and 156 measurements on diets based on dried forage. Explicative parameters included in the dataset were milk yield (MY), dry matter intake (DMI), body weight (BW), percentage of dry matter in diet (DM), percentage of concentrate in diet CONC, content of CP ingested with forage and concentrate qtCPf and qtCPc. Predictive equations were built by multiple regressions using the REG procedure and the stepwise statement to select the significant regressors. An external validation of the equation was performed from a dataset including 197 results of water flows collected from 43 studies gathered from the literature. Selected studies were obtained from bibliographic research in the CAB and from the bibliographic list of retained references. In this latter dataset ambient temperature was also collected.

Results The dataset used to build the predictive equations in the present study is unique because it included a large variability of FWI (varied from 2.3 to 140 kg/d) which is likely due to the large variability of % DM of diets (varied from 11.5 to 91.4%). The variable % DM was the first predictor of FWI and explained most of the variability with a partial R^2 of 0.57. The variability of urine volume was explained mostly by the qtCPf associated with DMI and that of fecal water was explained by CONC and DMI. Ambient temperature affected FWI, the mean prediction error (MPE) of FWI decreased when 26 data obtained at ambient temperature >25°C were eliminated (13.61vs 23.92). Fecal water was predicted from the product of fecal DM and the percentage of DM in feces (fDM %) to avoid negative prediction of low producing cows (Table 1).

Table 1 Prediction equations of FWI, urine volume and fecal water excretion

Prediction equations	Model adjustment			External validation	
	n	R^{adj}	rsd	n	MPE
FWI (kg/d)= 0.83 (±0.03) × DM + 3.22 (±0.23) × DMI + 0.92 (±0.07) × MY – 0.28 (±0.03) × CONC + 0.04 (±0.007) × BW –77.61(±6.08)	232	0.92	9.35	120	23.92
Urine water (kg/d)= $-2.2.10^{-4}(\pm 8.4.10^{-5}) \times qtCPf^{2} + 0.88 (\pm 0.11) \times DMI + 0.26 (\pm 0.03) \times qtCPf + 9.3.10^{-4} (\pm 10.5.10^{-5}) \times qtCPc^{2} - 19.77 (\pm 3.20)$	227	0.75	5.31	99	10.21
Faecal water (kg/d)= Fecal DM x fDM %				84	7.28
Fecal DM (kg DM)= $0.43 (\pm 0.009) \times DMI - 1.98.10^{-5} (\pm 3.09.10^{-6}) \times qtCPf^{2} - 2.30 (\pm 0.17)$	261	0.91	0.49		
fDM %= $0.04 (\pm 0.004) \times CONC - 0.03 (\pm 0.005) \times MY - 0.14 (\pm 0.03) \times DMI - 4.5.10^{-5} (\pm 1.03.10^{-5}) \times qtCPf^{2} + 16.28 (\pm 0.53)$	261	0.52	1.34		

Conclusions The main strength of the predictive equations proposed in the present study is that they were build from a dataset with a large variability of diet DM. Our predictive equation of urine volume was less precise than equation that included mineral intakes but it is simpler, as mineral intakes are difficult to assess in most farms. Also, it appears form the external validation that ambient temperature clearly affects water flows. This illustrates the necessity to integrate climatic parameters in the prediction equation .Further work will be necessary to integrate these parameters in such a way that they can be used across geographic localization.

References

Chapagain, A.K., Hoekstra, A.Y.2003. Research Report Series No.13, UNESCO-IHE.