A method to standardise meadow phenological observations: evaluation and applications

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A method to standardise meadow phenological observations: evaluation and applications

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Abstract. First hay cut is important for feed autonomy of livestock farms as it constitutes the largest part of the annual fodder production. Looking for the best compromise between fodder quality and quantity during first growth is therefore crucial to optimise meadow and feed rations management. In this context, phenology (i.e. development stages of plants) is a useful tool since it is closely related to fodder quality. Every spring since 1995, meadow phenological development is monitored on about 80 plots in western Switzerland to give farmers references of standardised development stage for different classes of elevation. The aims of this study are to present the "equivalent cocksfoot stage" method used to assess standardised phenological stage and to show the results of its robustness evaluation. The method was developed in 1994 on four years of phenological observations. Now with 21 years of data, it is possible to re-evaluate the method and to summarize trends of meadow spring development. Main findings are that relative development pace of the reference species is not changing with altitude gradient, nor with particular years (very late or early springs) and that there is an overall trend towards earlier meadow phenological development.

Keywords. Meadows – Phenology – Altitudinal gradient – Fodder quality.

Evaluation et applications d'une méthode utilisée pour standardiser les observations phénologiques des prairies de fauche

Résumé. *La première fauche est importante pour l'autonomie fourragère des élevages car elle représente la majeure partie du foin produit sur l'année. Aussi, chercher le meilleur compromis entre la qualité et la quantité lors de la première pousse est crucial pour pouvoir optimiser la ration et la gestion des prairies de fauche. Dans ce contexte, la phénologie offre un outil précieux, car elle est en lien étroit avec la qualité du fourrage. En Suisse romande, depuis 1995, le développement printanier de prairies de fauche est suivi sur environ 80 parcelles pour donner des références aux éleveurs sur le développement phénologique standardisé pour différentes classes d'altitude. Les buts de cette étude sont de présenter la méthode « stade équivalent dactyle » qui permet de standardiser le développement d'une prairie et d'exposer les résultats de l'évaluation de la robustesse de cette méthode. Cette méthode a été développée en 1994. Actuellement avec 21 ans d'enquêtes, il est possible de réévaluer la méthode et d'étudier de manière globale les données. Les constats principaux sont que les fonctions permettant de décrire le développement des espèces les unes par rapport aux autres ne changent ni avec l'altitude ni lors d'années particulières (printemps très précoce ou tardif) et qu'il y a une tendance vers un développement phénologique des prairies de plus en plus précoce.*

Mots-clés. *Prairie de fauche – Phénologie – Gradient altitudinal – Qualité du fourrage.*

I – Introduction

For mountain farming, grass has an essential role to play in cattle feed rations. Supplying cattle with fodder of quality in sufficient quantity has a positive impact on the feed ration, helping to reduce feeding concentrates, economic and environmental costs. Thus, assessing nutritive value of fodder before a cut is highly useful. It is therefore interesting to use phenological development as fodder quality indicator. Many studies (e.g. Buxton, 1996) show that forage nutritive value is linked

to the development stage of plants during the first growth. The increase in fibrous tissues like stem and spike and the ageing of the plant organs lead to a fall of digestibility of hay. Nonetheless, for meadows constituted of numerous species of different precocity, it is rather difficult to assess an average development stage precisely. This study presents the "equivalent cocksfoot stage" method to standardise the phenological observations (Meisser *et al.*, 2008). It has been developed in order to facilitate estimation of nutritive value of forage from multi-species meadows. Objectives of this study are (i) to evaluate the robustness of the method used to assess standardised phenological stage and (ii) to use the method for analysing 21 years of phenological observations.

II – Materials and methods

Every spring since 1995, phenological development of about 80 Swiss meadows is monitored by a network of observers (local advisers, teachers, farmers, etc.). Sites are distributed along an altitudinal gradient from 400 to 1,700 m of altitude, representing different climate conditions. The same protocol has been used since 1995, with the same phenological scale (8 stages describing morphological development). Ten meadows species (5 forbs and 5 grasses, common in Swiss grasslands) were chosen in order to have a panel of plants of different precocity. The 21 years of survey allowed to follow 1,750 plots and to record 80,480 observations (combinations of "date × species × site × year").

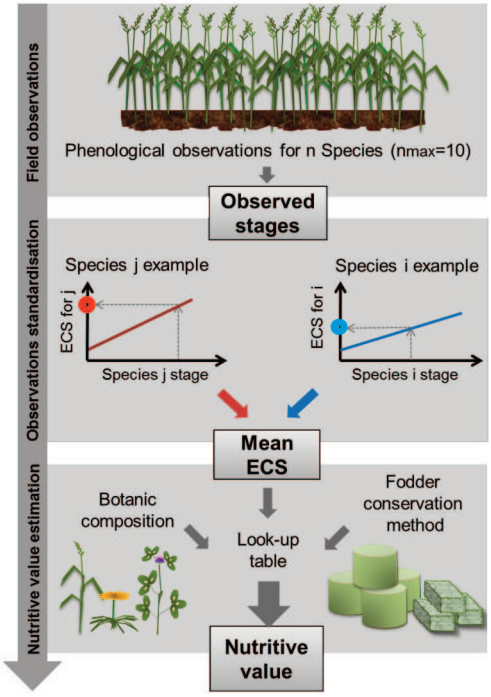

Fig. 1. Method to assess mean development stage of a meadow and its fodder nutritive value (ECS = "equivalent cocksfoot stage").

Cocksfoot (*Dactylis glomerata*) was chosen as the reference species because of its medium precocity and its ubiquity. The observed stages of the other nine meadow species are transposed into **"equivalent cocksfoot stages" (ECS):** a numerical index (ranging from 1 to 8) describing the stage that cocksfoot would display at the moment of observation.

This standardisation is done with nine equations given by each regression between cocksfoot observed stages and the other reference species stages. Those nine linear equations were established in 1994, after four years of phenological observations. The average of ECS obtained for the ten species at a particular date, characterise the mean stage of meadow development (Meisser *et al.*, 2008).

Each year, a table is published giving the mean development stage for 3-days periods and for 10 climate conditions (linked with altitude) (Amaudruz *et al.*, 2015). Those mean ECS stages are related to nutritive value parameters (Daccord *et al.*, 2006). Different parameters describing the nutritive value are proposed, such as "Net Energy for Milk production" [NEL MJ/kg DM] or "Crude Protein Content" [g/kg DM]. Those relations were established on a field experiment basis, where pure stands were grown, mowed and precisely analysed (Jeangros *et al.*, 2001). Those parameters are given for different botanical types and for three forage conservation methods. Figure1 shows the main steps to estimate nutritive value from observed phenological stages.

III – Results and discussion

1. Robustness evaluation of "equivalent cocksfoot stage" method

Statistical tests (ANOVA, Kruskal-Wallis) were computed to assess if the parameters of the nine ECS equations were different for some class of altitude or for some specific years (very early or late springs). It was found that the parameters are not significantly changing with classes of altitude nor with particular years (data not shown). Hence it shows that the method is robust and that the equations can be the same for all classes of altitude or for every year (even during particular years). This assertion is true for the amplitude of climate encountered over those 21 years and over the different climate conditions of the sites. The Figure 2 illustrates the stability of the regression with an example of "equivalent cocksfoot stage" relation for *Poa trivialis*. In a second step, all observations (i.e. 21 years) were then used to fit new regressions (one for each species) to build more accurate ECS relations based on more years of survey (Vuffray *et al.*, In prep.).

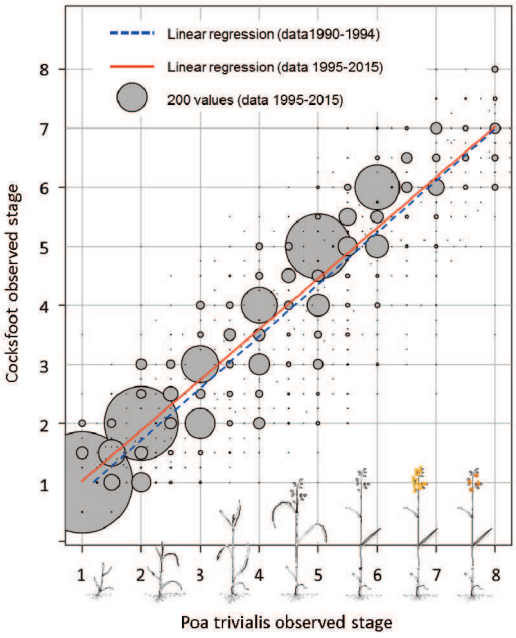

Fig. 2. Relation between cocksfoot and *Poa trivialis*. Dashed line: regression established in 1994. Solid line: regression established on data from 1995 to 2015 (7,979 obs., $R^2 = 0.814$, $y = 0.88 \cdot x - 0.4$). Points: data from 1995 - 2015 with size proportional to number of values (Vuffray *et al.*, in prep.).

2. Analysis of 21 years of phenological survey

As "equivalent cocksfoot stage" method is useful to sum up a large number of observations, it was used to analyse 21 years of survey. Mean ECS were calculated for each plot over spring growth periods and full heading dates were then extrapolated. Theil-Sen estimator was used to assess if there is an evolution in full heading dates over the 21 studied years in three main classes of altitude. Re-

sults illustrated in Figure 3, show that full-heading dates are becoming earlier every year in lowland altitudinal classes (around 2 to 3 days earlier every 10 years for fresh and very mild to mild classes). Temperature trends observed in Switzerland (Rebetez and Reinhard, 2007) are probably the reason of those earlier spring developments, as phenology is mostly driven by temperature.

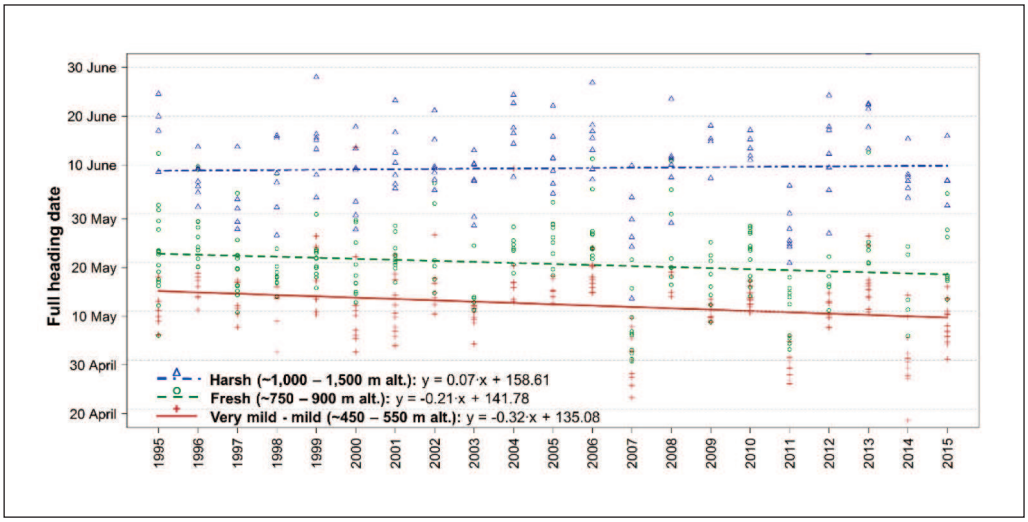

Fig. 3. Trend of full heading dates for three classes of climate (With Mann-Kendal trend test: P-value (harsh) = 0.56, P-value (fresh) = 0.02 and P-value (Very mild-mild) <0.001) (Vuffray *et al.*, In prep.).

IV – Conclusions

"Equivalent cocksfoot stage" method, despite its simplistic approach, allows to describe meadow mean phenological stages in a robust manner, across contrasting years and climate conditions. This method is used to give estimates of nutritive value, and is therefore recommended for practical issues. It is also appropriate to have global pictures of phenological changes as response of climate changes over several years.

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