A Method for Assessing Axial and Temporal Effects of the Leaf Sheath on the Flexural Stiffness of the Maize Stem

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Research Article

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Abstract

Background: The leaf sheath of many plants has been observed to influence both stiffness of the stem and ultimate strength. The leaf sheath has been implicated in studies of maize “greensnap” (or “brittle-snap”) failure. However, but the influence of the sheath is still not well understood and few methods exist for studying the influence of the sheath. The goal of this study was to develop a method for assessing longitudinal and temporal patterns of sheath influence on flexural stiffness. This metric of flexural stiffness was chosen because it is non-destructive and has been shown to be highly predictive of bending strength.

Results: A three-point bending test method was successfully developed for assessing the influence of the sheath on flexural stiffness. The method relies upon comparisons between pairs of tests at the same location (sheath present vs. absent). The influence of the sheath was statistically significant in all varieties tested. The test method provided insights into the longitudinal and spatial variation of sheath influence: sheath influence appears to be closely related to maturity since both spatial and temporal patterns of influence mirror the sigmoidal maturation patterns previously observed in maize stalks.

Conclusions: The paired nature of this test method increases statistical significance while the non-destructive feature of this test allows for multiple tests along the length of the stalk. This method can be used to provide new insights

regarding how the leaf sheath influences stalk flexibility (and therefore strength). Preliminary results indicate that the influence of the sheath changes over the life span of the plant in parallel with maturation patterns. However, further studies will be needed to confirm this hypothesis more broadly and to study additional issues such as heritability and the influce of genotype and environment on sheath influence.

Full-text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the manuscript can be downloaded and accessed as a PDF.

Figures

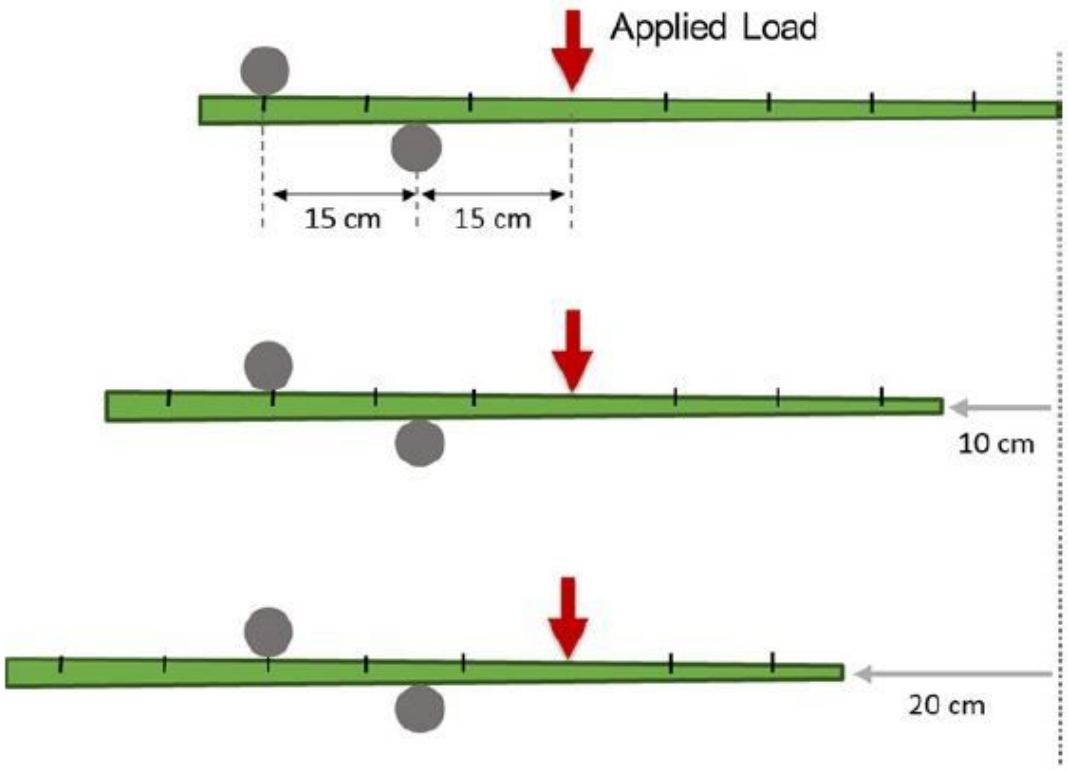

Figure 1

An illustration of the test arrangement used in this study. Supports are represented by gray circles while the red arrow represents the applied force. The gray horizontal arrows indicate the process of shifing the stalk to the left as the test process progresses.

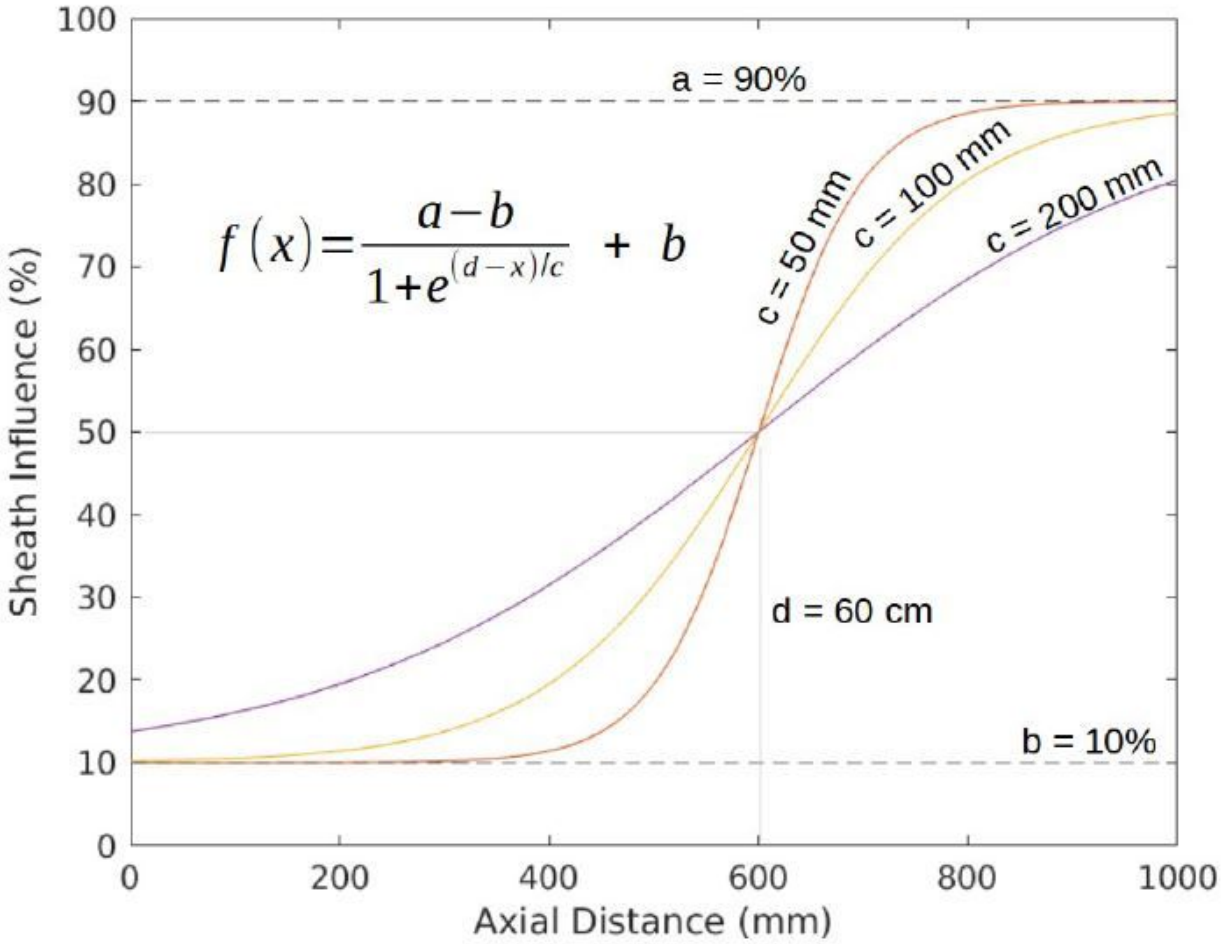

Figure 2

Three sigmoid curves with their associated coefficient values and the sigmoid curve equation.

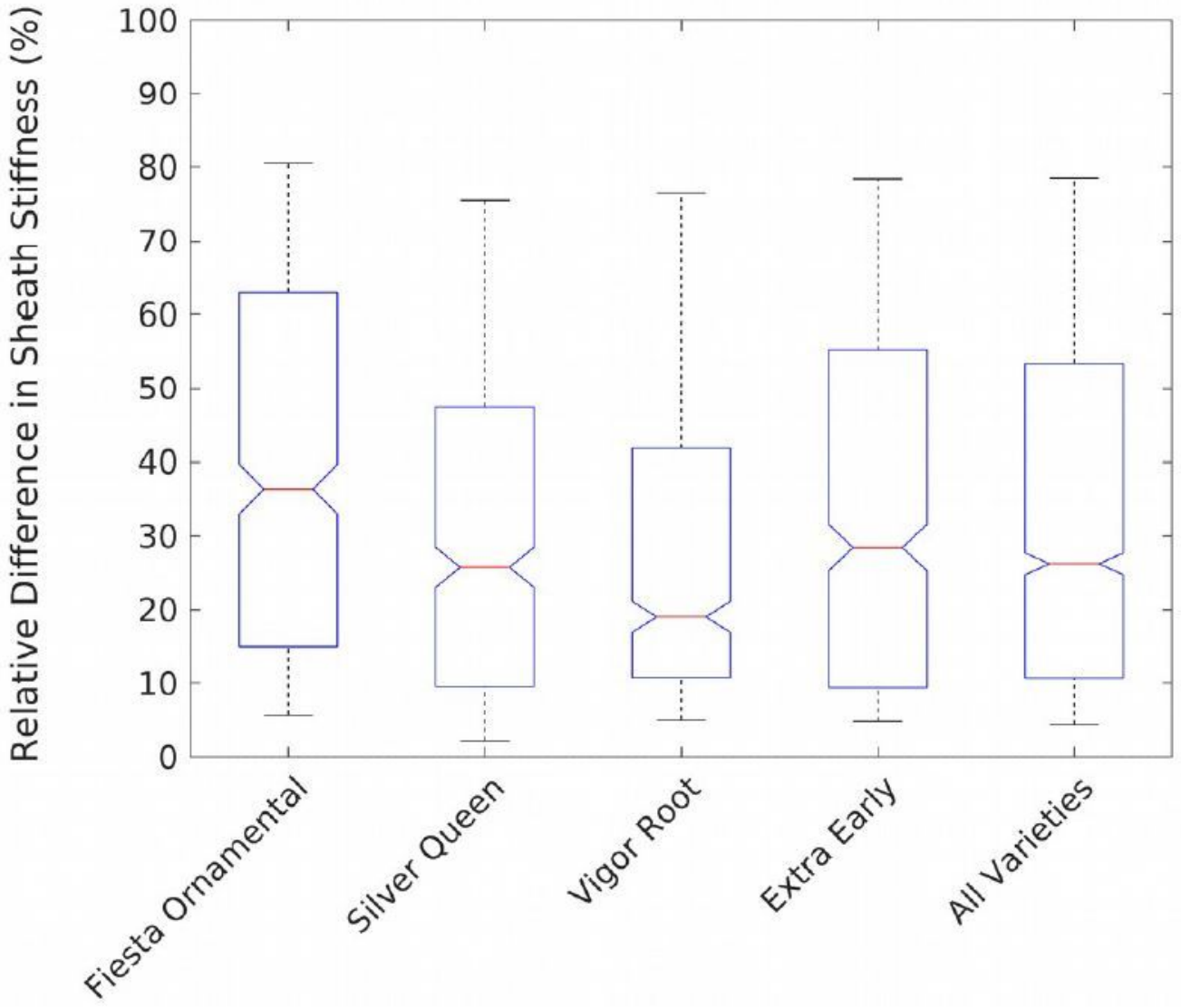

Figure 3

Box plots depicting the influence of the leaf sheath on flexural stiffness for each variety tested, and all varieties combined (last box). Notches indicate statistical significance.

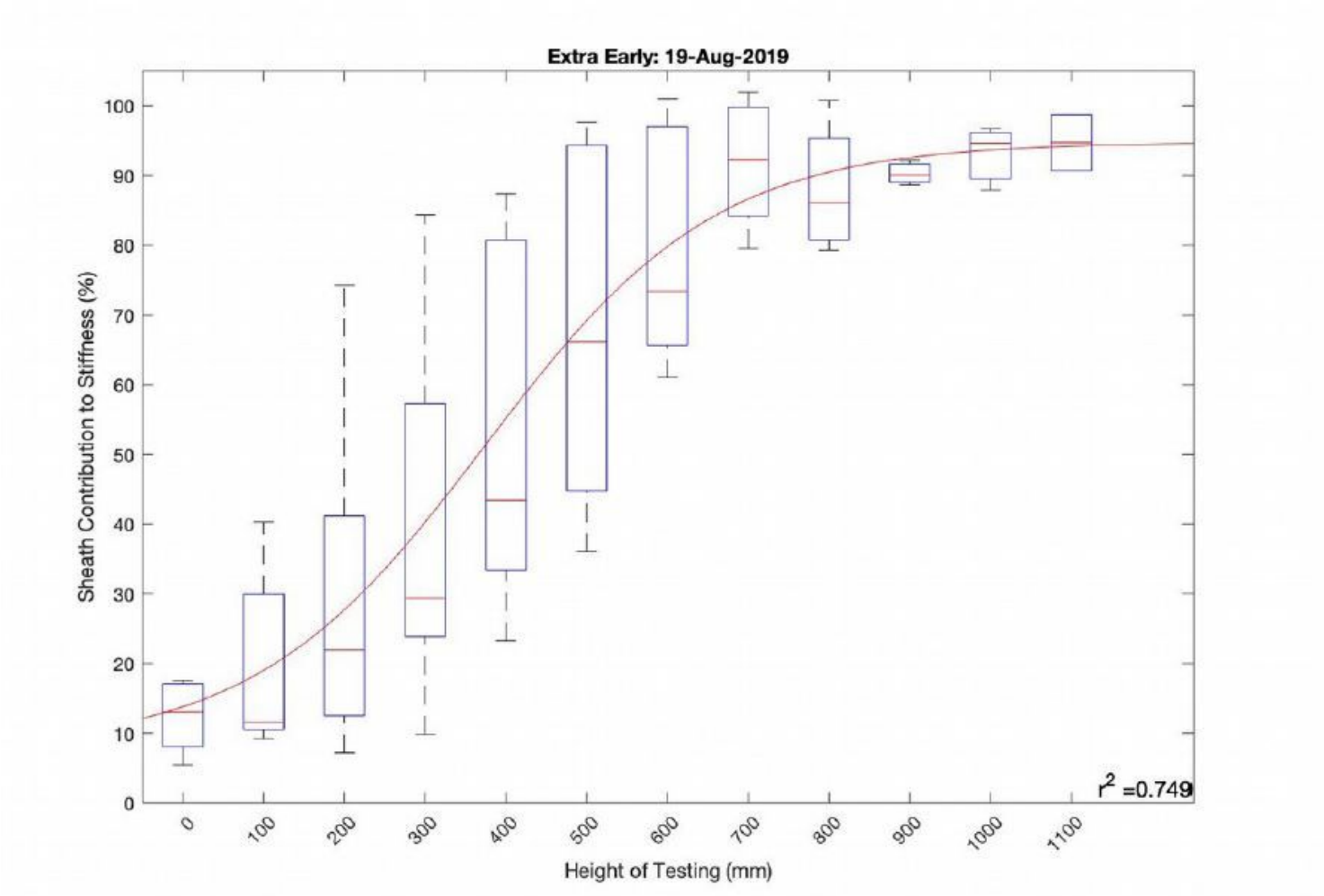

Figure 4

Representative chart showing the sigmoid curve fitted to test results as a function of axial position (additional charts available in the supplementary data that accompanies this paper).

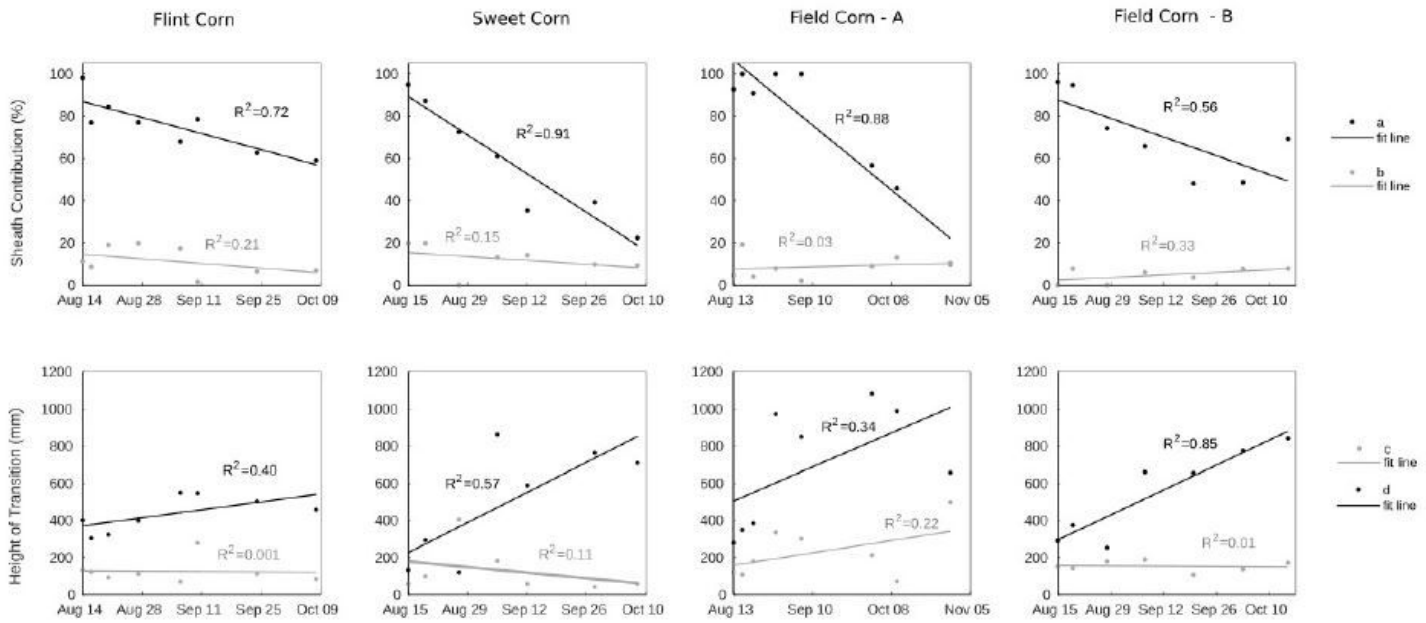

Figure 5

Plots of coefficient values over time for each of the four varieties. Consistent patterns were observed for coefficients a and d (shown in black). In contrast, inconsistent patterns were observed for coefficients b and c (shown in gray).

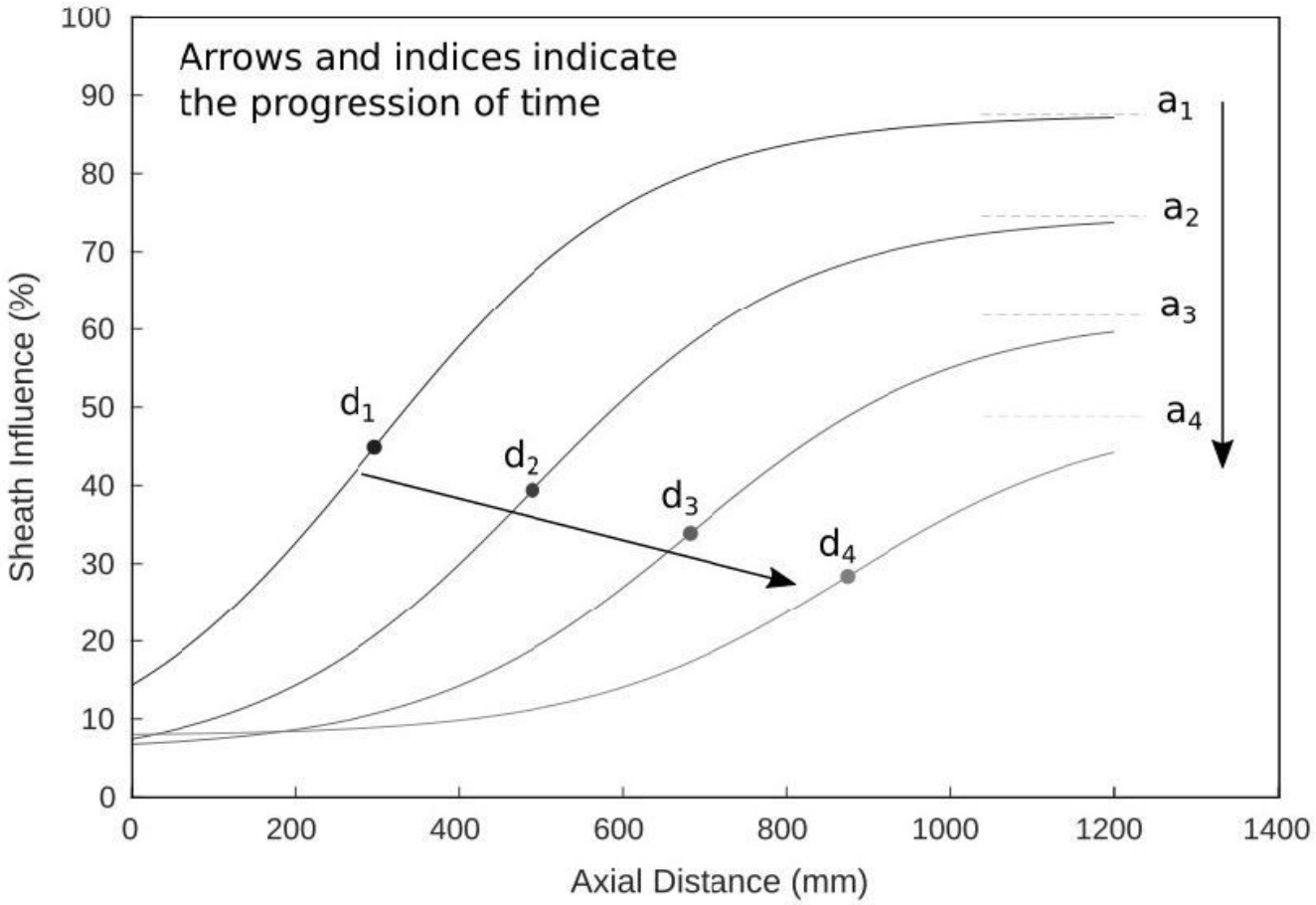

Figure 6

Illustration of the typical progression of coefficients a and d, and the resulting progression of sigmoid curves.