

## Online Resource 2: Model effects for papillae length, width, and SEF.

The described models for papillae length, width, and SEF:

Papillae length  $\sim$  sex + age + age<sup>2</sup> + feeding rank + month + year

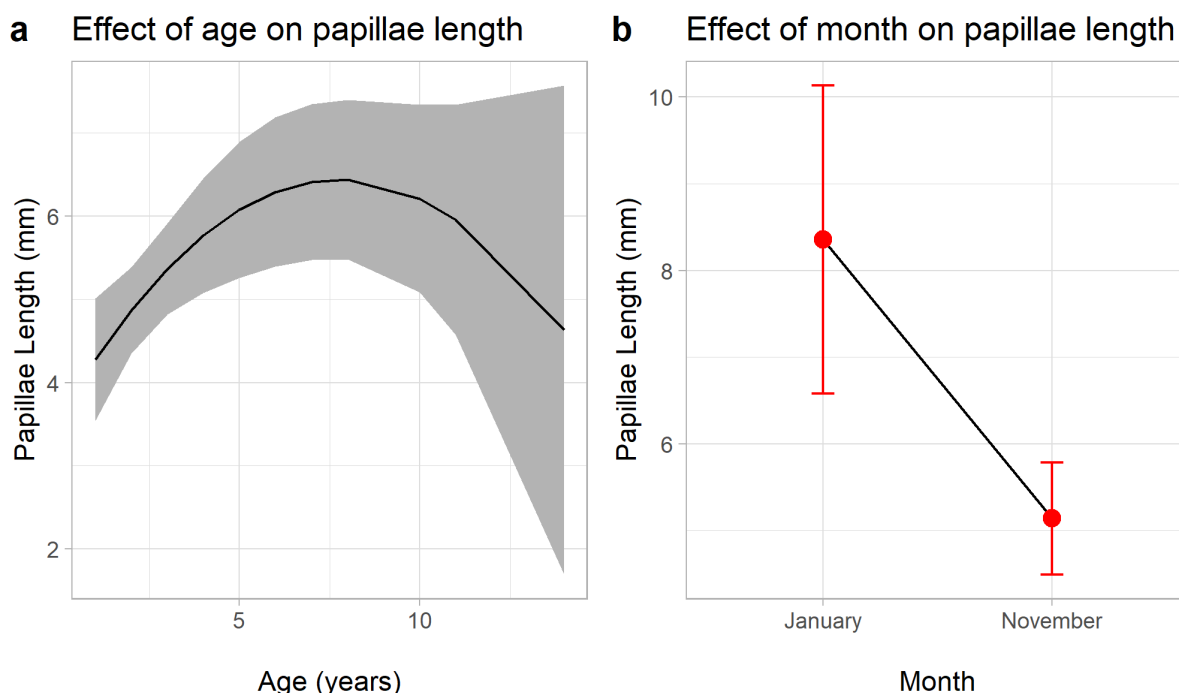
Papillae width  $\sim$  sex + age + age<sup>2</sup> + feeding rank + month + year

SEF  $\sim$  sex + age + age<sup>2</sup> + feeding rank + month + year

### Papillae Length

**Table 1.** Model coefficients estimated by the linear regression model used to describe the effect of sex, age, feeding rank, month, and year on ventral rumen papillae length in 71 sampled deer. Sex was a categorical predictor with two levels: female (reference category) and male. Month of sampling was also a categorical predictor with two levels: January (reference category) and November. Year was a categorical predictor with three levels: 2019 (reference category), 2020, and 2021.

| Model Coefficients      | $\beta$ Estimate | Standard Error | Z Value | P Value |
|-------------------------|------------------|----------------|---------|---------|
| <i>Sex (Male)</i>       | 0.02264          | 0.53245        | 0.043   | 0.96622 |
| <i>Age</i>              | 0.73068          | 0.28073        | 2.603   | 0.01151 |
| <i>Age<sup>2</sup></i>  | -0.04690         | 0.02300        | -2.039  | 0.04562 |
| <i>Feeding Rank</i>     | 0.04092          | 0.17034        | 0.240   | 0.81095 |
| <i>Month (November)</i> | -3.21834         | 0.93343        | -3.448  | 0.00101 |
| <i>Year (2020)</i>      | -0.59517         | 0.92537        | -0.643  | 0.52245 |
| <i>Year (2021)</i>      | 0.35917          | 0.63841        | 0.563   | 0.57570 |

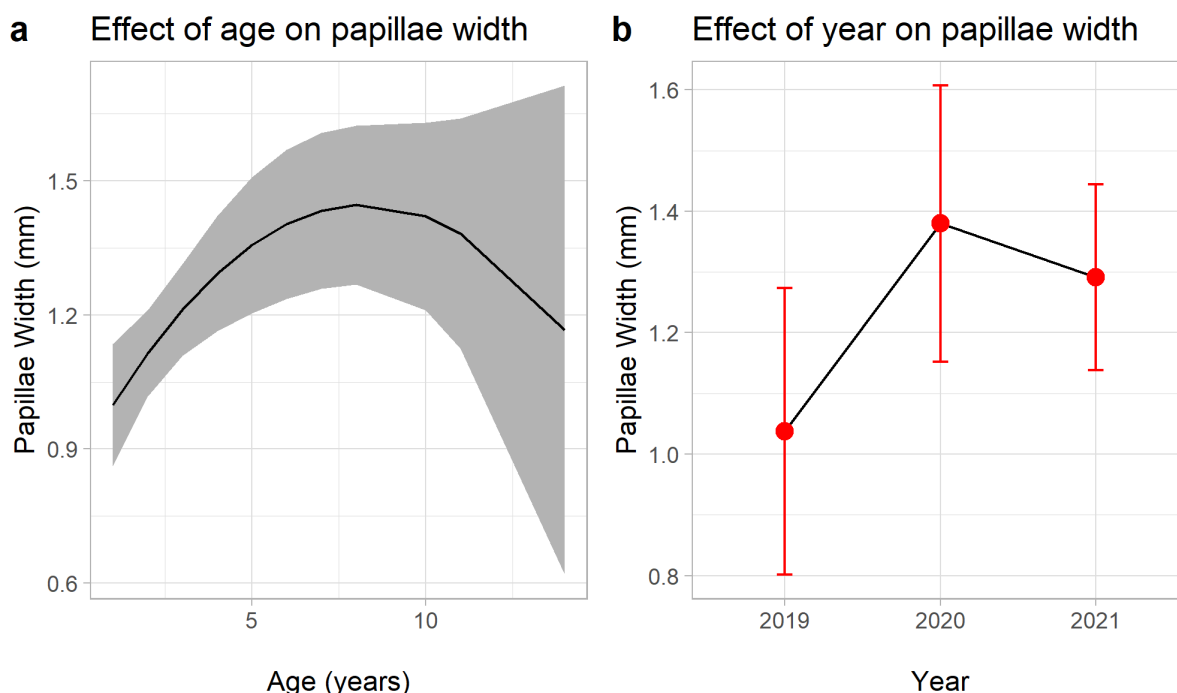


**Fig. 1** The model effects of (a) age and (b) month on ruminal papillae length of the 71 sampled fallow deer at Phoenix Park, Dublin. The shaded area and bars represent the 95% confidence intervals.

## Papillae Width

**Table 1.** Model coefficients estimated by the linear regression model used to describe the effect of sex, age, feeding rank, month, and year on ventral rumen papillae width in 71 sampled deer. Sex was a categorical predictor with two levels: female (reference category) and male. Month of sampling was also a categorical predictor with two levels: January (reference category) and November. Year was a categorical predictor with three levels: 2019 (reference category), 2020, and 2021.

| Model Coefficients      | $\beta$ Estimate | Standard Error | Z Value | P Value |
|-------------------------|------------------|----------------|---------|---------|
| <i>Sex (Male)</i>       | 0.099390         | 0.099105       | 1.003   | 0.31976 |
| <i>Age</i>              | 0.140299         | 0.052252       | 2.685   | 0.00926 |
| <i>Age<sup>2</sup></i>  | -0.008494        | 0.004281       | -1.984  | 0.05160 |
| <i>Feeding Rank</i>     | -0.005607        | 0.031706       | -0.177  | 0.86020 |
| <i>Month (November)</i> | 0.233203         | 0.173740       | 1.342   | 0.18433 |
| <i>Year (2020)</i>      | 0.342215         | 0.172241       | 1.987   | 0.05129 |
| <i>Year (2021)</i>      | 0.253618         | 0.118828       | 2.134   | 0.03671 |

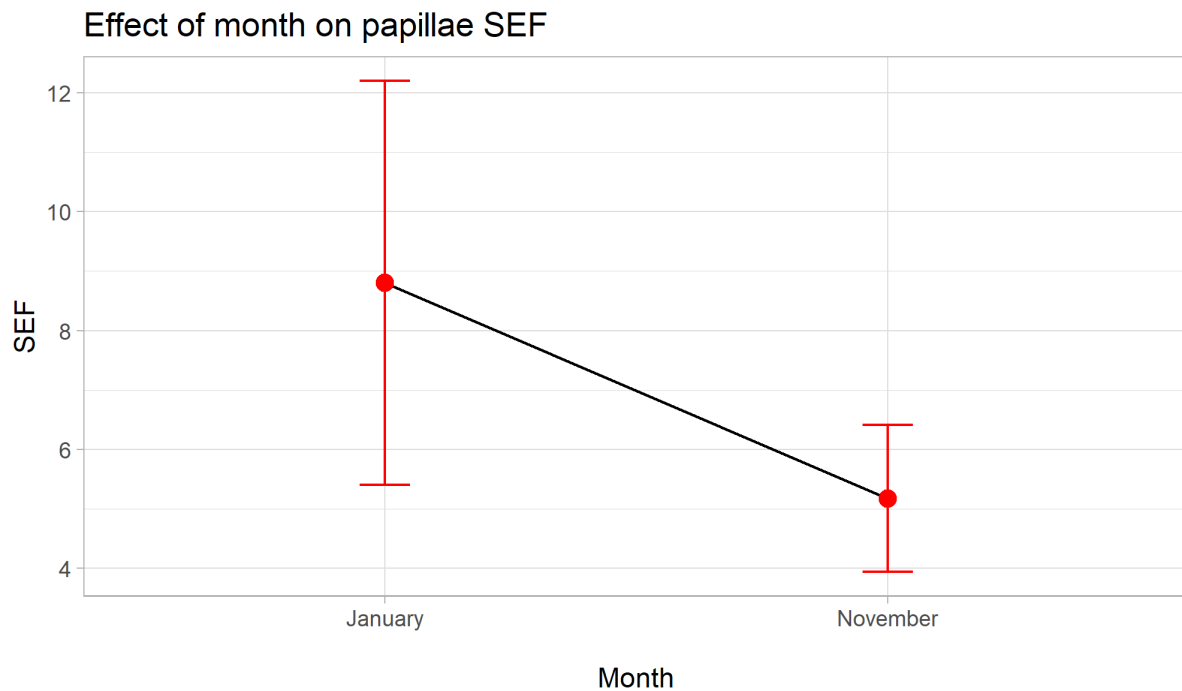


**Fig. 2** The model effects of (a) age and (b) year on ruminal papillae width of the 71 sampled fallow deer at Phoenix Park, Dublin. The shaded area and bars represent the 95% confidence intervals.

### Papillae SEF

**Table 1.** Model coefficients estimated by the linear regression model used to describe the effect of sex, age, feeding rank, month, and year on ventral rumen SEF in 71 sampled deer. Sex was a categorical predictor with two levels: female (reference category) and male. Month of sampling was also a categorical predictor with two levels: January (reference category) and November. Year was a categorical predictor with three levels: 2019 (reference category), 2020, and 2021.

| Model Coefficients      | $\beta$ Estimate | Standard Error | Z Value | P Value |
|-------------------------|------------------|----------------|---------|---------|
| <i>Sex (Male)</i>       | 1.09726          | 1.01685        | 1.079   | 0.2847  |
| <i>Age</i>              | 0.78837          | 0.53613        | 1.470   | 0.1464  |
| <i>Age<sup>2</sup></i>  | -0.04732         | 0.04393        | -1.077  | 0.2855  |
| <i>Feeding Rank</i>     | 0.21417          | 0.32531        | 0.658   | 0.5127  |
| <i>Month (November)</i> | -3.62593         | 1.78263        | -2.034  | 0.0462  |
| <i>Year (2020)</i>      | 0.70561          | 1.76725        | 0.399   | 0.6910  |
| <i>Year (2021)</i>      | 1.14554          | 1.21921        | 0.940   | 0.3510  |



**Fig. 3** The model effect of month on papillae SEF in the ventral rumen of the 71 sampled fallow deer at Phoenix Park, Dublin. The bars represent the 95% confidence intervals.

Neither sex nor feeding rank had significant effects on papillae length, width or SEF (Table 1-3). Age was a significant driver of change in papillae length ( $P = 0.01$ ) and width ( $P = 0.01$ ). Juvenile deer had shorter and thinner (4.3mm and 1.0mm) papillae compared to adults (6.4mm and 1.4mm) (Fig. 1a and Fig. 2a), likely due to the transition from a milk to forage diet and rumen development. Papillae length was also influenced by month ( $P = 0.001$ ) and showed a decrease in length from 8mm in January to 5mm in November (Fig. 1b), which may indicate seasonal variation in forage quality. However, a greater portion of deer were sampled in November ( $N = 61$ ) compared to January ( $N = 10$ ). Papillae width had small scale yearly changes, significantly increasing from 1.04mm in 2019 to 1.38mm in 2020 ( $P = 0.05$ ), and decreasing to 1.29mm in 2021 (Fig. 2b). SEF was not affected by age ( $P = 0.1$ ), but was influenced by month ( $P = 0.01$ ). Deer had a greater ruminal absorptive area in January (SEF = 9) compared to November (SEF = 5) (Fig. 3).