

# Heart Rate Logging in Free-Ranging Mammals

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## Introduction

Recent technology developments in bio-logging enables researchers to monitor physiological parameters, such as body temperature (Tb) and heart rate (HR) in undisturbed settings.

In Norway, domestic sheep graze unfenced in the forest and on mountain pastures during the summer. This semi-domestic setting provides an excellent opportunity to validate quality, and use of bio-loggers in free ranging conditions.



**Figure 1.** Subcutaneous heart rate logger implantation in an adult sheep with local anesthesia. (1) Subcutaneous incision, (2) sterilized logger is placed in the subdermal pocket, (3) wound is sutured and iodine is applied (4).

## Materials & Methods

Thirty HR loggers (Milli-HRT, Star Oddi, Iceland) were implanted subcutaneously in twenty lambs in two different flocks, and in ten ewes (Fig.1) in one of the flocks. All sensors were sterilized using propylene gas.

The HR was measured based on 3 sec ECG strips sampled at 200Hz with 1, 2 or 10 minute intervals. Lambs and ewes were observed on the summer pasture and behavior was recorded. During three periods, distributed over the summer, the logger stored raw ECG data, enabling the validation of the HR data.

For each measurement, the loggers store a quality index (QI) that gives an automatic assessment of the signal quality. Star-Oddi suggests analyzing only HR measurements above a certain quality threshold. On 1493 ECG strips below this threshold the assessment was manually repeated and compared to the QI of the logger.

For 600 randomly selected ECG strips R-R intervals were manually measured and the HR calculated. These manual measurements confirmed the validity of the loggers' HR measurements.

## Discussion

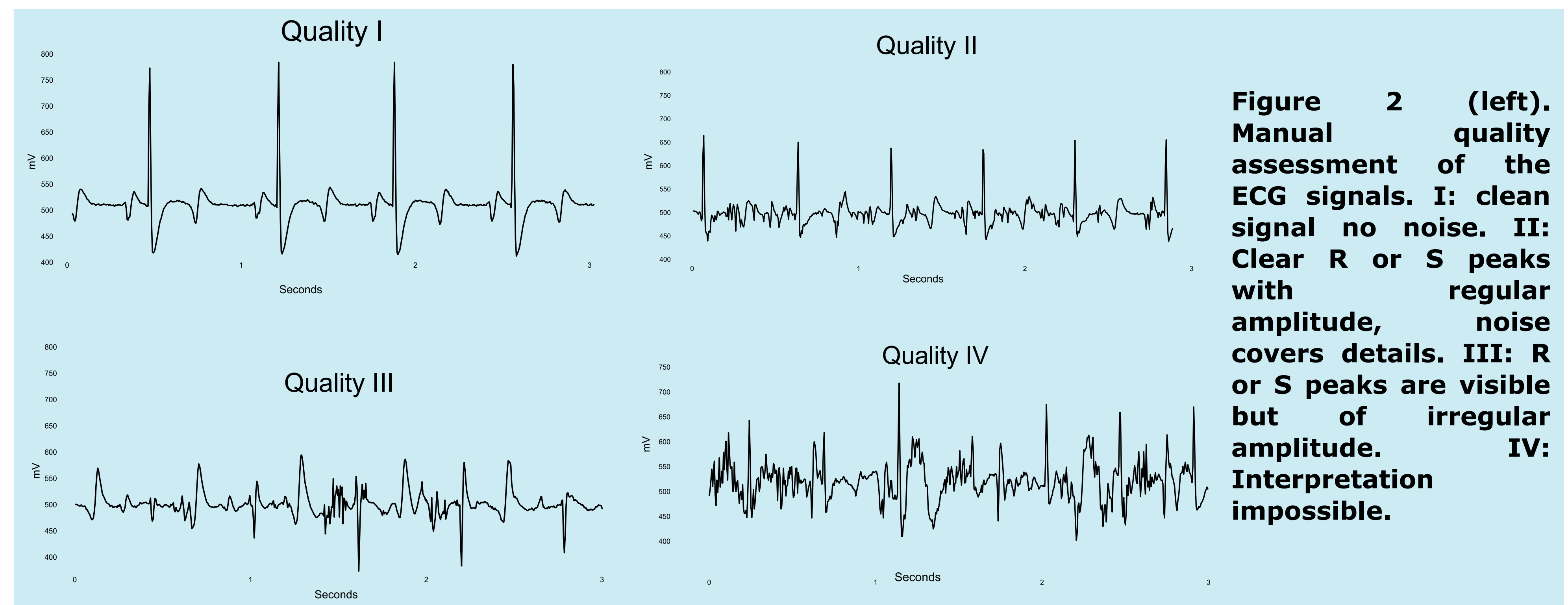
- We conclude that the Star Oddi HR loggers are suitable for monitoring HR in free-ranging large mammals.
- The quality assignment of the loggers corresponded with the manual ECG based evaluation.
- The ECG based HR values did not differ from the HR values stored on the logger.
- The loss of a logger can be problematic and should be considered in the study design.
- In this study, the loss was higher in the herd infected by Anaplasma, an infectious tick born disease.
- Further knowledge is needed to obtain immune response to implants in interaction with infectious diseases.
- The slight drop in HR during the summer is opposing earlier reported trends and has to be further investigated.

## Results

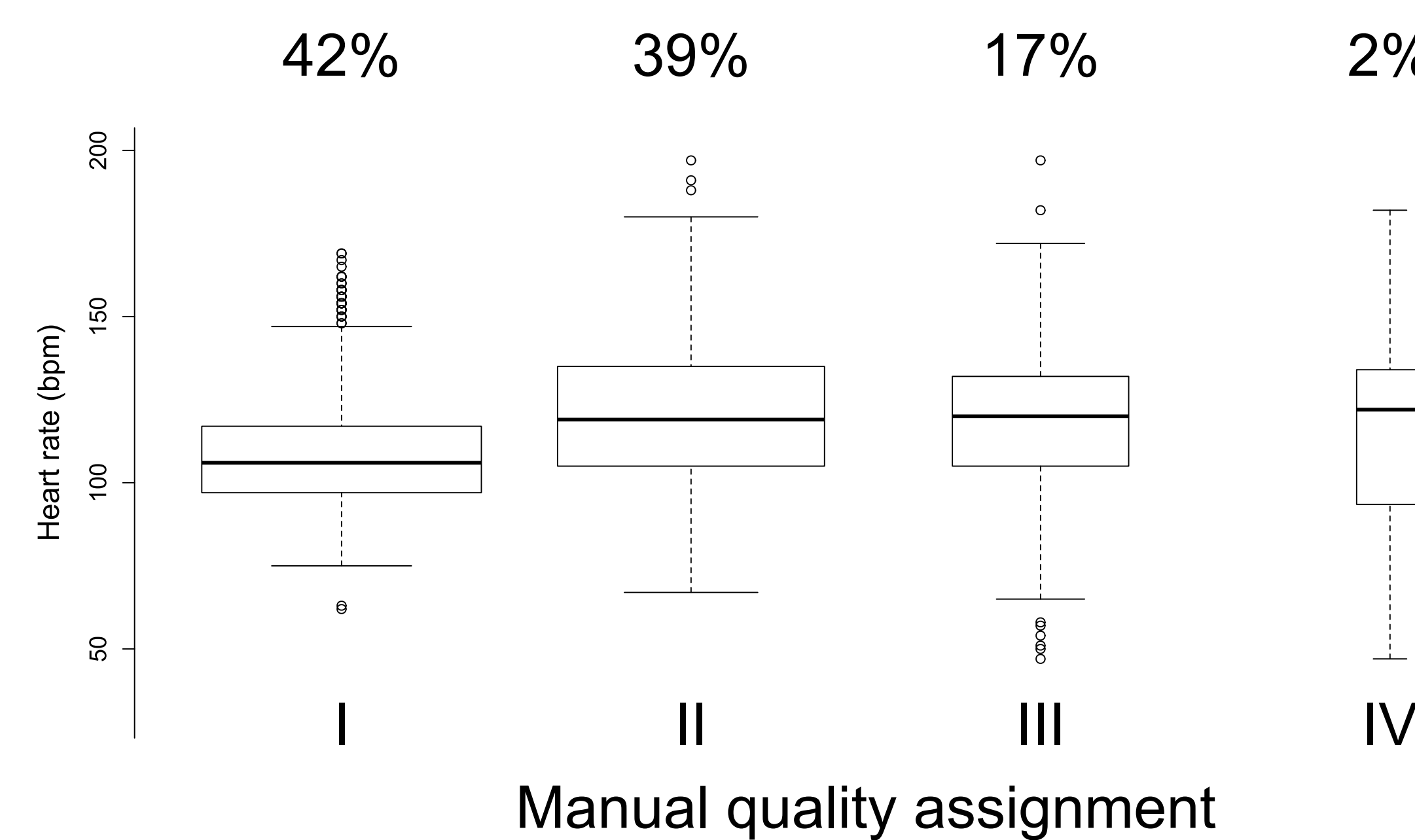
Of the 30 loggers, 22 loggers provided 454.775 HR measurements that could be retrieved and downloaded, with 88% of the measurements being above the on-board quality threshold. Eight loggers were ejected by the animal mainly in one of the two study herds. Five loggers had power issues and data could only be retrieved until the time of failure. Table 1 summarizes the findings for minimum, maximum, mean active and mean passive HR.

	Min HR [bpm]	Max HR [bpm]	Mean active HR (SD)	Mean passive HR (SD)
Adult females	68	143	106(17); n=215	90(13); n=164
Juvenile lambs	78	197	128(18); n=237	112(13); n=139

**Table 1.** ECG confirmed minimum and maximum heart rates and mean heart rate from observed active or passive animals.



**Figure 2 (left).** Manual quality assessment of the ECG signals. I: clean signal no noise. II: Clear R or S peaks with regular amplitude, noise covers details. III: R or S peaks are visible but of irregular amplitude. IV: Interpretation impossible.

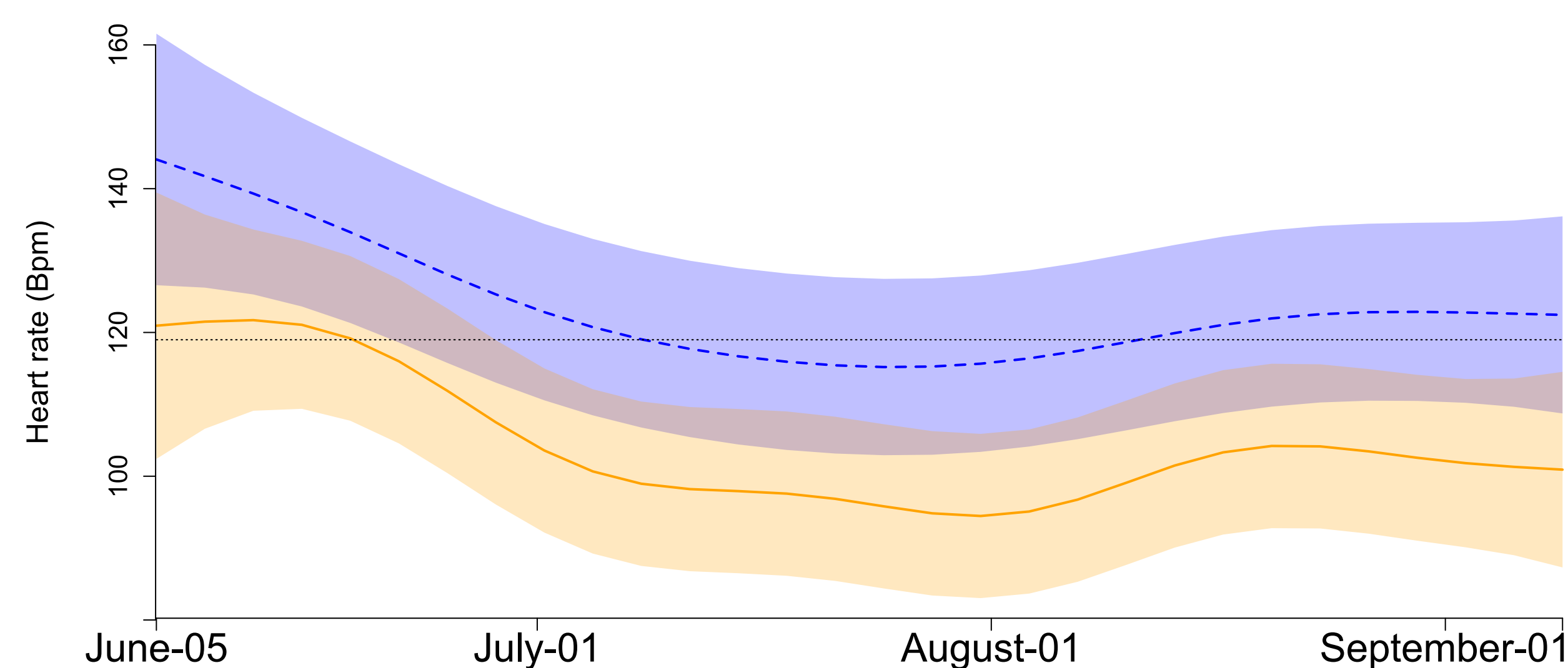


From the 1493 ECG strips manually assigned, the HR logger assessed the quality in >98% of the measurements correctly (Fig.3).

The HR measured by the logger and the ECG based HR did not differ ( $t=0.9$ ,  $p=0.35$ ,  $df=599$ ).

Adult ewes had a lower HR than juveniles and both decreased over summer (Fig. 4).

**Figure 3 (left).** Proportions of the manual quality assignments for measurements below the automatic quality threshold.



**Figure 4 (left):** Fitted (GAMM) heart rate values from adult ewes (orange solid) and juvenile males (blue dashed) compared to the standardized juvenile females (dotted black).