

Supplementary Information for

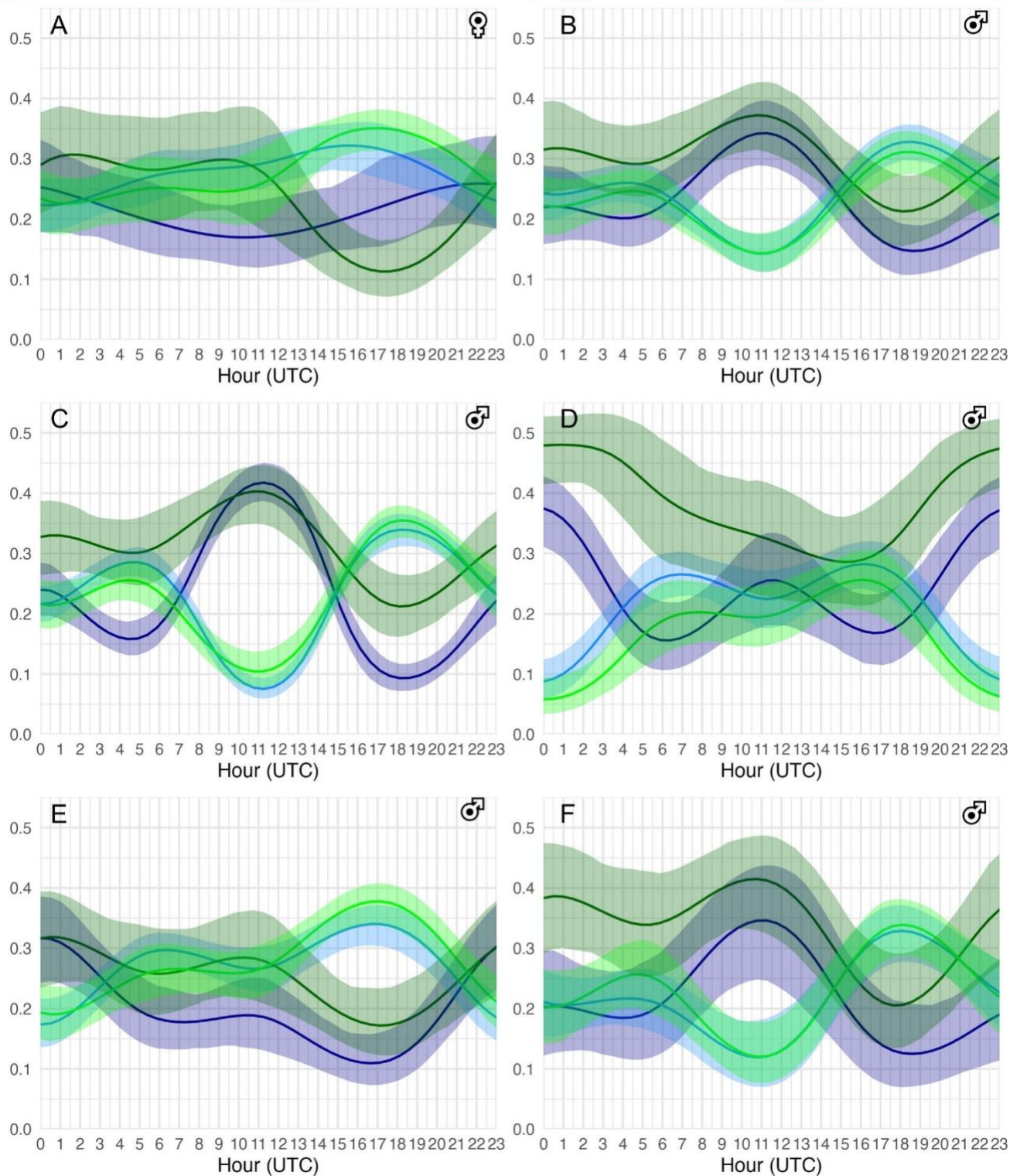
A hidden Markov framework for joint identification of animal activity modes and movement phases

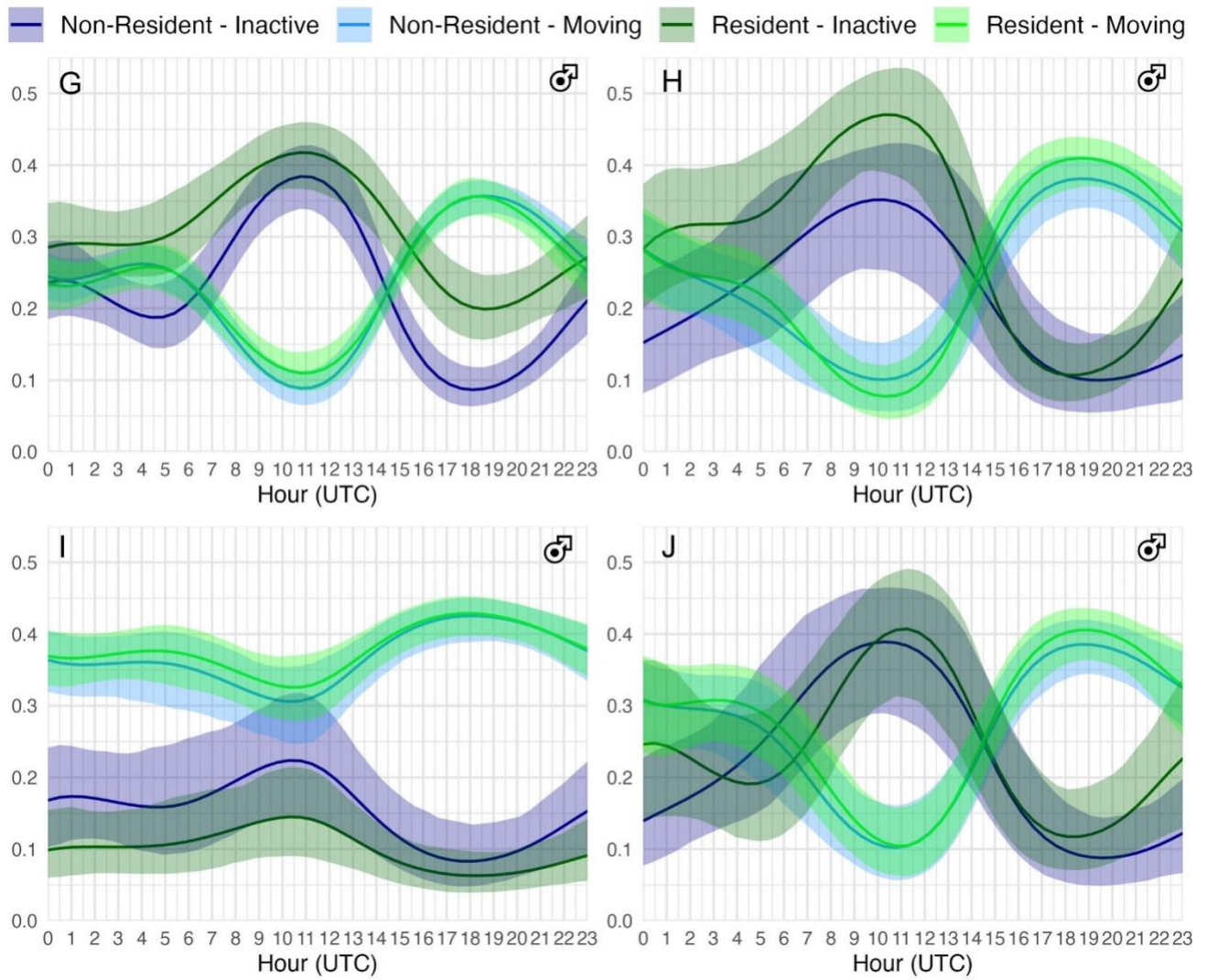
Cisneros-Araujo, P., Gastón, A., Cubero, D., Pinto, D., Saura, S., & Rodriguez de Rivera, Ó. (2026). A hidden Markov framework for joint identification of animal activity modes and movement phases. *Landscape Ecology*. <https://doi.org/10.1007/s10980-026-02304-3>

Transition probability matrix for the 6-state hidden Markov model resulting from the combinations of two latent processes—activity mode (inactive *I* or moving *M*) and movement phase (non-resident *NR*, partially resident *PR* and fully resident *FR*). In the matrix, *c* refers to the resulting transitions between states in the asymmetric coupled hidden Markov model.

$$\Gamma^{(6)} = \begin{pmatrix} c_{NRI \rightarrow NRI} & c_{NRI \rightarrow NRM} & c_{NRI \rightarrow PRI} & c_{NRI \rightarrow PRM} & c_{NRI \rightarrow FRI} & c_{NRI \rightarrow FRM} \\ c_{NRM \rightarrow NRI} & c_{NRM \rightarrow NRM} & c_{NRM \rightarrow PRI} & c_{NRM \rightarrow PRM} & c_{NRM \rightarrow FRI} & c_{NRM \rightarrow FRM} \\ c_{PRI \rightarrow NRI} & c_{PRI \rightarrow NRM} & c_{PRI \rightarrow PRI} & c_{PRI \rightarrow PRM} & c_{PRI \rightarrow FRI} & c_{PRI \rightarrow FRM} \\ c_{PRM \rightarrow NRI} & c_{PRM \rightarrow NRM} & c_{PRM \rightarrow PRI} & c_{PRM \rightarrow PRM} & c_{PRM \rightarrow FRI} & c_{PRM \rightarrow FRM} \\ c_{FRI \rightarrow NRI} & c_{FRI \rightarrow NRM} & c_{FRI \rightarrow PRI} & c_{FRI \rightarrow PRM} & c_{FRI \rightarrow FRI} & c_{FRI \rightarrow FRM} \\ c_{FRM \rightarrow NRI} & c_{FRM \rightarrow NRM} & c_{FRM \rightarrow PRI} & c_{FRM \rightarrow PRM} & c_{FRM \rightarrow FRI} & c_{FRM \rightarrow FRM} \end{pmatrix}$$

Non-Resident - Inactive Non-Resident - Moving Resident - Inactive Resident - Moving





Supplementary Fig. 1. Stationary state probabilities (y-axis), with 95% confidence bands, as a function of time of day (x-axis; hour in UTC) for 10 individual Cantabrian brown bears (1 female in panel A and 9 males in B-J) representing a range of circadian activity patterns.