SUPPLEMENTARY METHODS for

Marine biorhythms: bridging chronobiology and ecology

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Red knot radio tracking

We studied the roosting and foraging behavior of red knots *Calidris canutus canuts* wintering in the Baie d'Aouatif in Parc National du Banc d'Arguin, Mauritania, West Africa (19˚53'N, 16˚17'W) and foraging on intertidal mudflats between 9 January and 13 February 2013 [1,2]. We equipped 46 individuals with a 6 g tag glued to the skin of their rump [3]. Every second each tag emitted a specific radio signal. Up to nine radio receivers positioned in the area registered the time of arrival of the tag-specific signal. The differences in signal arrival times between the stations were used to calculate the tag's position [2,4,5].

To test for circadian and tidal foraging rhythms, we used the bird's distance to the nearest high tide roost as a proxy for foraging behaviour (for the intertidal area and known roost sites see Fig. A1). We only used tag positions with an estimated error below 125 m. For each half hour we calculated the median position and hence median distance to the nearest roost. As birds differ in where they forage and roost, we standardized the distance data within each bird by dividing each distance by the bird's furthest distance represented by 95 percentile of all its distance. Thus 0 represents the roost and 1 the farthest distance from the roost for a given bird. We then analysed only standardized distance smaller than 2 and used individuals with more than 50 hours of recording. In this way, we obtained 81,635 half-hourly distances from 42 red knots (median [range] = 19 [2-34] days per bird.

For each bird we then tested whether the standardized off-roost distance for each bird was related to (a) 'tide' specified as time difference to and from the closest high tide (ranging from -6.7 to 6.7 h with 0 representing high tide) and transformed to radians (by multiplying the hours by π and dividing by 6.2) and (b) 'time of day' (in hours) transformed to radians (by multiplying the hours by π and dividing by 12). Both variables were then represented by a sine and cosine function. To minimize temporal auto-correlation (and hence pseudo-replication) we have sampled only 15% of the data for each individual with individual data-points spaced more than 1 hour apart. We then report tidal or circadian pattern if the respective 95% credible intervals for sin or cosine estimates did not overlap zero. For plotting purposes, we back-transformed the predictions of standardized distance to km by multiplying the predictions for a given bird by its 95 percentile of all its distance (i.e. by the value that we initially used to standardized the distance).

We used the statistical software R [6]. We used the 'sim' function from the 'arm' R package and a non-informative prior-distribution [7, 8] to create a sample of 5,000 simulated values for each model parameter (i.e. posterior distribution). We generated model predictions by the medians, and the uncertainty of the predictions by the Bayesian 95% credible intervals represented by 2.5 and 97.5 percentiles (95% CI) from the posterior distribution of 10,000 predicted values.

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Supplementary References

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