Erratic spatiotemporal vegetation growth anomalies drive population outbreaks in a trans-Saharan insect migrant

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Hu et al. (1) propose that vegetation growth in “kernel” regions of the Savanna/Sahel during January/February is key to explain population abundances of the painted lady butterfly (Vanessa cardui) in Europe. We identify issues in their rationale and provide evidence toward an alternative scenario.

First, Hu et al. (1) conjecture that, in exceptional years, substantial breeding of V. cardui occurs in the African Savanna/Sahel at the peak of the dry season, but no ground-truthed evidence is provided. This hypothesis challenges previous research in Africa, including models based on breeding data (2, 3), and the authors refer to their results as “counterintuitive.” We inspected the leaf area index (LAI) in Hu et al.’s kernels and show that the values are steadily low, with no peaks in the dry season that may indicate substantial herbaceous coverage at any scale (Fig. 1A). We argue that the low signal of vegetation growth found by Hu et al. likely corresponds to woody plants (Fig. 1B), which may store water (4, 5) but are not V. cardui larval hosts (2, 3).

Second, Hu et al.’s (1) approach assumes that key breeding localities explaining outbreaks are recurrent across events, excluding the possibility that migratory steps and breeding groups from successive generations could be linked every year to slightly different configurations. Additionally, their models were constrained to account for only a few predetermined regions and months. Given the low philopatry of V. cardui and the erratic nature of exceptional climatic events, we demonstrate a different approach that avoids a predetermined spatiotemporal partition. We inferred monthly, highly positive vegetation growth anomalies in the species’ African range, using a suite of satellite-derived layers, for the 1994–2020 period, and visually inspected their geographical distribution (Fig. 2). We find that 1) the four major butterfly abundance peaks documented in Europe were closely preceded by vegetation growth anomalies outside the kernels; 2) these anomalies were located at different suitable spatiotemporal breeding grounds in North Africa, the Middle East, and the Afrotropics.
Fig. 2. Time series plots of butterfly abundance in Europe (1994–2020): Butterfly Monitoring Scheme (BMS) densities (black lines) and Global Biodiversity Information Facility (GBIF) overall counts (dashed gray lines). High positive vegetation growth anomalies (Z score $\geq 3$/EOT $\geq 500$; green lines) in Africa and the Middle East from November to June consistently predate outbreaks (orange rectangles). Vegetation anomalies are based on the normalized difference vegetation index (NDVI) and the enhanced vegetation index (EVI) from the global inventory monitoring and modeling system (GIMMS) (7) and the moderate resolution imaging spectroradiometer (MODIS) (8) satellite databases (0.08° and 0.05° spatial resolution, respectively), and two algorithms: standardized difference vegetation index (SDVI) and empirical orthogonal teleconnection (EOT) (9). Vegetation growth anomalies at Hu et al.’s (1) kernels (red lines) are also shown, but no peaks are detected preceding outbreaks. Maps indicating high positive vegetation anomalies (green pixels) are shown for the four main historical outbreaks in Europe. Red polygons delimit Hu et al.’s kernels, depicting the very few monthly vegetation growth anomalies (red pixels) in January of the outbreak year.

(3); 3) the contribution of the kernels to the overall winter and early spring vegetation growth in Africa was minimal; and 4) remarkable variability exists between remote sensing methods, which could affect correlations.

Hu et al.’s (1) modeling exercise, although limited by arguable assumptions, illustrates that climate in Africa could explain abundances of insects migrating to Europe, a view that we share. However, we dispute the nature and strength of the correlation found in their kernels. Based on our analyses, we argue that it is highly unlikely that this correlation represents substantial breeding and the source of outbreaks, although it could represent a side effect of biologically meaningful climatic anomalies occurring in other areas/times. Our results provide a grounded alternative scenario where the strongest vegetation growth events preceding butterfly outbreaks in Europe constitute the most logical environmental drivers, even if their unpredictable localization renders them hardly detectable using pixel-based correlations. This pattern agrees with the view that populations of migratory insects are dynamic and opportunistically exploit vegetation within their suitable seasonal range, making them true spatiotemporal riders of erratic vegetation resources.

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