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PHYSIOLOGICAL STRESS AND REPRODUCTIVE SUCCESS OF BUFF-TAILED BUMBLEBEES (*BOMBUS TERRESTRIS*) IN AGRICULTURAL LANDSCAPES

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Pollination is an important ecosystem service. Agricultural intensification and land expansion have negative effects on pollinator diversity. Insect pollinators remain under constant stress due to changes in the landscape, invasive pathogens, decreases in the amount of floral resources and detrimental effects of pesticides. We investigated whether habitat quality affects bumblebee body concentration of carbon (C) and nitrogen (N), the C/N ratio and *B. terrestris* reproductive success, each considered stress indicators.

METHODS: we placed commercially produced bumblebee hives in two contrasting agricultural landscapes during the plant flowering season. Hives were removed along with the generation change of bumblebee colonies.



Figure 1. An oilseed rape field (photo by Ronalds Krams).

Oilseed rape (*Brassica napus*) fields

Higher pollen and nectar abundance, monoculture, longer blooming season.

Apple tree (*Malus domestica*) orchards

Lower pollen and nectar abundance, higher floral diversity, relatively short blooming season.



Figure 2. An apple tree orchard (photo by Ronalds Krams).

We identified individuals of each bumblebee colony and counted the number of hatched and unhatched worker and queen cocoons as indicators of colony reproductive output. Afterward, bumblebees were dried in a laboratory drying furnace and homogenized to prepare biological samples for determination of C and N concentrations, and ratios, performed with a chemical element analyzer.

RESULTS:

Heavier reproductive individuals:

A potential offspring size/count tradeoff?

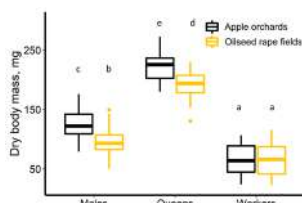


Figure 3. Dry body mass of bumblebees.

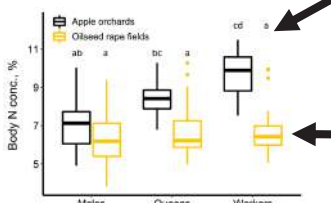


Figure 4. Body nitrogen concentration of bumblebees.

As expected:

More muscle for flying means more protein and more nitrogen.

Not expected:

Why did queens and workers lose their nitrogen?

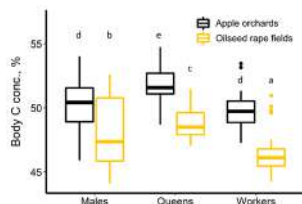


Figure 5. Body carbon concentration of bumblebees.

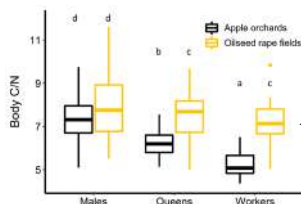


Figure 6. The body carbon-to-nitrogen ratio of bumblebees.

Higher C/N in rapeseed fields:
The general stress paradigm suggests more significant stress.

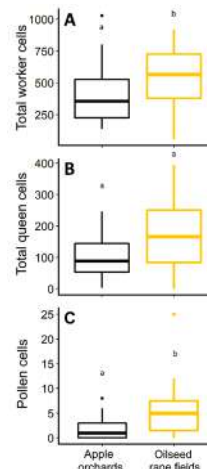


Figure 7. Reproductive parameters of bumblebees in apple tree orchards and oilseed rape fields. The higher number of worker cells (A) and more pollen cells (C) suggest higher reproductive output and more intense resources gathered in oilseed rape fields despite higher stress levels.

CONCLUSIONS:

- Bumblebee reproductive output was significantly higher in oilseed rape fields, a more productive habitat, than in apple orchards, a more natural habitat;
- Higher reproduction rates were achieved at the cost of physiological stress, evidenced by a significantly higher C/N ratio observed in bumblebees inhabiting oilseed rape fields;
- The C/N ratio of *B. terrestris* individuals was lower in apple orchards, where bumblebees had significantly higher body N concentrations.
- Body elemental analysis is a reliable method to assess the stress levels of bumblebees and can add to the understanding of pollinator decline reasons.

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Pollination is a vital ecosystem service, yet agricultural intensification continues to pose significant challenges for insect pollinators. Our study investigated the effects of habitat quality on the physiological stress and reproductive success of the buff-tailed bumblebee (*Bombus terrestris*), focusing on variations in body elemental composition as indicator of stress. We placed commercially produced bumblebee hives in two contrasting agricultural landscapes - oilseed rape (*Brassica napus*) fields and apple tree (*Malus domestica*) orchards, throughout the flowering season. Our results revealed that reproductive output was significantly higher in oilseed rape fields compared to apple orchards, which was accompanied by an elevated carbon-to-nitrogen (C/N) ratio, a recognized stress marker. Bumblebees inhabiting apple orchards exhibited higher nitrogen concentrations, indicating lower physiological stress. These findings suggest that while more productive habitats enable increased reproductive investment, they do so at the cost of heightened stress levels. Our study underscores the importance of ecological stoichiometry in understanding the trade-offs between habitat productivity, pollinator fitness and stress, offering new perspectives for pollinator conservation in agricultural landscapes.