Climate change has positive and negative effects on invasive mountain pine beetles

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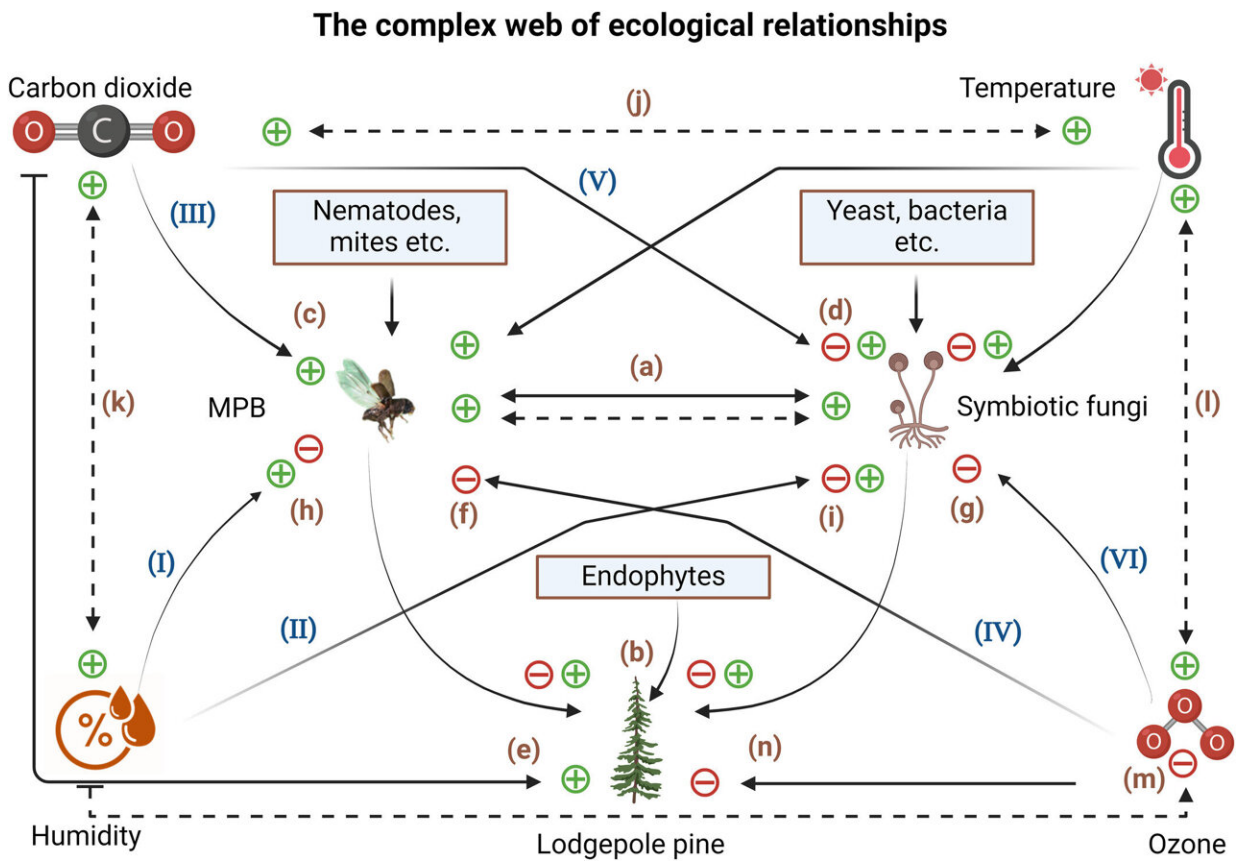

Impact of climatic variables on the functional network of ecological interactions among the mountain pine beetle, their host tree (lodgepole pine) and symbiotic fungi. Credit: *Global Change Biology* (2024). DOI: 10.1111/gcb.17207

Climate change is hampering mountain pine beetle reproduction but also

appears to slightly benefit the invasive insect in other ways, new University of Alberta research shows.

The mixed scenario provides "a deeper understanding of dynamics that are crucial to building effective forest management and conservation strategies in the face of ongoing environmental changes," says Rashaduz Zaman, who led the study published in *Global Change Biology*. Zaman is working toward a Ph.D. in forest biology and management from the Faculty of Agricultural, Life & Environmental Sciences.

The research—the first to show specifically how the mountain pine beetle is affected by elevated levels of two greenhouse gases, carbon dioxide and ozone—provides new insight into how the insect and its relationship with beneficial fungi are influenced by climate change.

The findings signal a mix of potentially positive and negative implications for the beetle.

More CO_2, more beetles?

On an apparent upside for the insect—but detrimental for the lodgepole forests it attacks—lab experiments showed that exposure to higher levels of carbon dioxide accelerated the beetle's typical one-year cycle of egg-laying, hatching and maturing by at least five days, which could in turn lead to more rapid population growth and higher infestation rates.

The finding could potentially aid in creating better management strategies against the beetle's invasion of boreal forests, says Zaman.

The beetle invades trees both near and far, but because accelerated development could make the insect larger, it would be able to fly farther, making it more difficult to pinpoint and manage far-flung infestation sites.

"This insight is crucial for mountain pine beetle management because it suggests that areas with clusters of attacked trees nearby, resulting from short-distance dispersal, may be more manageable from a control perspective," Zaman notes.

"Concentrating control efforts in these relatively small areas could be more effective in containing infestations and preventing their spread to new locations. Forest managers and policy-makers can tailor their management strategies to target specific areas more efficiently."

As well, the researchers were surprised to find that despite the beetle's reduced reproduction rates, within a single generation, the higher ozone exposure also provided a better ability to survive against a parasitic fungus that usually kills the insect.

"Brood beetles demonstrated normal behavior despite the environmental challenges that affected their parents, which could be due to an increased response from defense-related genes," Zaman suggests.

Experiments conducted under less humid, drier conditions—which are expected to come with climate change—also altered saprophytic fungi, a type that is usually harmful because it outcompetes the beetle's beneficial fungi.

But lower humidity flipped that equation, providing beneficial fungi for the beetle broods to feed on, Zaman notes.

"This could ultimately benefit the beetles, with a higher likelihood of reproduction success and range expansion."

Ozone may impair reproduction

There were also detrimental effects for the beetle, the research showed.

Exposure to higher levels of ozone reduced the insect's ability to deposit its larvae in the tree bark, meaning fewer eggs were laid.

The production of pheromones—airborne chemical signals the beetles use to communicate in numbers large enough for mating and reproduction—was also altered.

That means their ability to mate could be impaired, Zaman says. "Our research showed that if the beetles couldn't find mating partners, they abandoned the tree without mating, so no eggs were laid. And even when some did mate, they produced fewer broods."

When exposed to high levels of ozone, the insects produced about 10 broods per log, compared with 100 broods produced in more ambient conditions.

As well, the research showed that elevated levels of the two greenhouse gases affected the growth of the beneficial fungi the beetle carries with it to trees. Such fungi perform valuable services for the insect, including providing minerals and nutrients.

While some of the species showed enhanced growth from higher exposure to the greenhouse gases, others declined.

"That means changes in the growth rate of these symbiotic fungi may cause irregularities in the normal functioning of the beetle's life cycle and invasion strategy."

Overall, the study shows just how complex the effects of climate change are for the beetle and its beneficial fungal partners, says U of A forest entomologist Nadir Erbilgin, who supervised the study.

"While both are affected by changing environmental conditions, the

effects aren't uniform between them, which makes it difficult to understand the dynamics for predicting and managing the impacts of climate change on forest ecosystems."

Having a better handle on those dynamics could help improve strategies for managing the mountain pine beetle, such as monitoring programs, scientific modeling and genetic research, he adds, noting that his lab is further exploring several of those aspects and also plans to conduct studies spanning more of the insect's broad geographical range.

"All of this knowledge can help scientists, policy-makers and conservationists work towards more targeted, effective strategies for mitigating mountain pine beetle outbreaks to minimize the damage to forests."

More information: Rashaduz Zaman et al, Unraveling the multifaceted effects of climatic factors on mountain pine beetle and its interaction with fungal symbionts, *Global Change Biology* (2024). DOI: 10.1111/gcb.17207

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