European Commission

Science for Environment Policy

Biodiversity slows spread of pesticide resistance

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The ability of organisms to adapt to toxic chemicals like pesticides is essential for their survival, but also an agricultural annoyance. This study shows that interactions between different species can delay the development of pesticide resistance and therefore suggests that biodiversity supports effective pest management.

When pest species are exposed to toxic chemicals, like pesticides, they can evolve genetic changes that confer resistance to the harmful effects. These genetic changes can be passed on to offspring and become widespread in future populations. Due to increasing levels of environmental pollution, such genetic adaptations have become important for the survival of diverse populations.

This form of genetic adaptation is also relevant to agriculture, where traditional pest control strategies are struggling to cope with the rise of resistance. Genetic resistance has been recorded against 300 insecticide compounds in over 500 pest species.

This study considered pesticide resistance in southern house mosquitoes (*Culex quinquefasciatus*), where a mutation in the *ace-1* gene confers resistance against several types of insecticides. However, under normal conditions with no insecticide toxins, individuals with this mutation have lower survival rates than those without it.

The negative effect of pesticide resistance under non-toxic conditions increases when there are additional ecological stressors present. Studies have shown that predation, food shortages and parasites all increase the effect pesticide resistance has on survival rates. These stressors also accelerate the 'genetic recovery' of the population – the time taken for a population to become dominated by non-resistant individuals once again after a pesticide has been removed from the environment.

However, previous studies have not considered how environmental stressors affect the spread of resistance. To answer this question, the researchers in this study exposed southern house mosquitoes, a common carrier of disease and target of pesticides, to chlorpyrifos, a widely used insecticide.

The researchers reared mixed populations of susceptible and resistant mosquitoes over six generations. Four populations were cultivated in the absence of any other species, and therefore experienced high competition for resources within their own species (intraspecific competition). In another four populations, 10–20% of the mosquito larvae were randomly harvested twice per week to simulate predation. The final four populations were raised in an environment containing water fleas to generate competition between different species (interspecific competition). All experiments were carried out twice: with and without the pesticide.

The researchers identified rapid genetic changes over the course of the six month experiment. The frequency of the resistance gene occurring decreased from 50% to 28% in populations which were not exposed to the pesticides. By contrast, in the populations that were exposed to the pesticides, the frequency increased to 76%.

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However, this rate of genetic adaptation was slowed by predation and by interspecific competition with waterfleas. To understand why, the team developed and ran a simulation model. Their simulation suggests that non-selective predation and the competition between different species reduced the intraspecific competition among the mosquito larvae. Susceptible individuals affected by the insecticide likely interact less with the competing species than resistant individuals. Therefore, interspecific competition predominantly affects the resistant individuals, decelerating their spread within the mosquito population.

This study shows that interspecific competition and predation can delay genetic change, prolonging the time taken for a resistance allele to become fixed within a population. As diverse communities contain a lot of species interactions, they support the management of pesticide resistance. This study therefore shows a new benefit of biodiversity.

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