Prickly holly reveals ability to adapt genetics to environmental change

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Prickly holly leaves are a traditional Christmas decoration, from wreaths adorning homes, to greeting card scenes. Yet, look closer at a holly tree and while some leaves are prickly, others are not. Scientists writing in the *Botanical Journal of the Linnean Society* believe variations within a single tree are the combined result of herbivore activity and molecular responses to environmental change.

"The ability of an organism to change its characteristics in response to environmental variations is known as phenotypic plasticity and it is a key driving factor in the evolution of a species," said Dr Carlos Herrera from National Research Council of Spain (CSIC) in Seville. "In plants this is often seen in eye-catching changes to leaves and flowers related to variable growing conditions. Every gardener knows that leaves produced in deep shade and under full sun are often very different in size and shape."

However, this variation of leaf forms can also take place within a single tree of many different species, and it is known as heterophylly. Dr Herrera partnered with Ms Pilar Bazaga, also from CSIC, to explore this phenomenon in European holly (*Ilex aquifolium*) a pioneer species, with a strong ability to accommodate to changing conditions.

"Heterophylly is often witnessed in holly trees, where some leaves are prickly, a defense against herbivores, while others are non-prickly, with smooth margins and no defense," said Dr Herrera. "We wanted to find out if this variation was a response to environmental changes and if this

took place without wider genetic change, that is, without alteration of the organism's DNA sequence."

"Heterophylly is a widespread phenomenon occurring in many different types of plants," Dr Mike Fay, Chief Editor of the Botanical Journal of the Linnean Society. "By coincidence it is also a conspicuous feature of ivy (*Hedera helix*), another plant associated with Christmas decorations."

Such change is known as epigenetics and to explore the biological mechanics behind this process the scientists turned to methylation, a chemical modification of DNA which does not alter the DNA sequence of an organism, but can have decisive consequences.

DNA methylation profiles, heterophylly and herbivory were studied in 40 holly trees from a forest in South Eastern Spain. 39 were found to be heterophyllous, with branches displaying prickly and non-prickly leaves in neighbouring positions.

The team then explored the feeding activity of browsing deer and goats to see if this was the environmental factor driving this genetic diversity. The team found a significant relationship between recent feeding and the growth of prickly leaves, noting that under the height of 2.5 meters, the average reach of an adult red deer, leaves were consistently pricklier.

The results revealed a clear link herbivore activity, phenotypic plasticity and epigenetic changes involving modifications in the methylation status of cytosine, one of the building blocks of DNA molecules. This supports the theory that epigenetic variation alone can be a source of variation in natural plant populations that does not require changes in the DNA sequence.

"An increasing number of studies support the idea that the presence of spines and prickles in plants is a response to herbivore activity, and our

research suggests this is the case with holly," concluded Dr Herrera. "The ability of plants to respond to environmental changes through quick epigenetic modifications makes also one to feel a bit more optimistic about plant survival in a quickly changing world."

More information: Herrera. C, Bazaga. P, 'Epigenetic correlates of plant phenotypic plasticity: DNA methylation differs between prickly and nonprickly leaves in heterophyllous Ilex aquifolium (Aquifoliaceae) trees', *Botanical Journal of the Linnean Society*, December 2012, DOI: 10.1111/boj.12006

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