

Rare Excitatory Amino Acid from Flowers of Zonal Geranium Responsible for Paralyzing the Japanese Beetle

Pelargonium x hortorum L.H. Bailey (from *Pelargonium zonale* hybrids) includes some of the most horticulturally desirable cultivars from the *Pelargonium* genus. *Pelargonium* species possess chemically based defenses effective against insects and pathogens, and extracts have been used for medicinal purposes. In 1920, scientists discovered that Japanese beetles (JB) become quickly paralyzed after consuming flower petals from zonal geranium. This phenomenon was confirmed in 1929, 1999, and 2003, but the chemical responsible for inducing paralysis had remained unknown until a recent report by Ranger *et al.* (2011).

The zonal geranium cultivar 'Nittany Lion Red' was selected for use in experiments aimed at isolating and identifying the paralytic compound. Plants were potted and maintained under greenhouse conditions and flower petals were hand collected and stored in the dark until analysis. Ground petals were extracted, applied to an agar-based diet, and introduced to a female JB as a food source. During experiments, paralysis of the JB was determined by an inability to right themselves after being inverted, along with the legs being extended and rigid rather than held closely to their bodies (Figure 1). Initial experiments determined a polar solvent was most effective at extracting the paralytic compound from the petals. Subsequent activity experiments used high performance liquid chromatography to isolate the paralytic compound.

High-resolution–mass spectroscopy and nuclear magnetic resonance (^1H , ^{13}C , COSY, heteronuclear sequential quantum correlation, heteronuclear multiple bond correlation) analysis identified the paralytic compound as quisqualic acid ($\text{C}_5\text{H}_7\text{N}_3\text{O}_5$), a known but rare agonist of excitatory amino acid receptors. Optical rotation measurements and chiral HPLC analysis determined an L-configuration. Geranium-derived and synthetic L-quisqualic acid demonstrated the same positive paralytic dose–response when introduced to the JB (Figure 2).



Figure 1. Paralyzed JB after consuming agar infused with L-quisqualic acid from flower petals of zonal geranium. Arrow indicates portion of agar consumed.

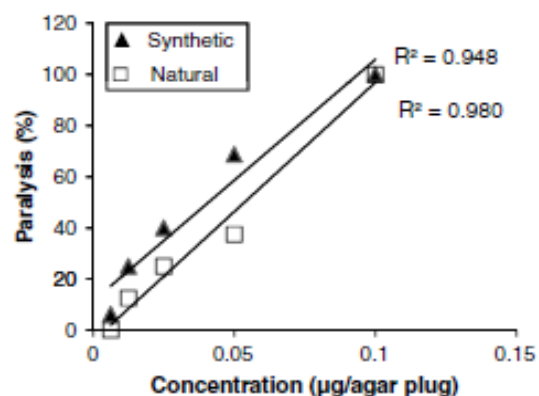


Figure 2. Dose–response of natural, geranium-derived and synthetic L-quisqualic acid. Paralysis was assessed 3 h after the JB initiated consumption.

These findings demonstrate zonal geranium is a previously unknown and unexpected source of L-quisqualic acid. Paralysis of an insect induced by consumption of a plant-derived excitatory amino acid has not previously been demonstrated. Establishing zonal geranium as a natural source of L-quisqualic acid presents a unique opportunity for the pursuit of botanically based formulations for insect pest management.

For further reading:

Ranger, C. M., R. E. K. Winter, A. P. Singh, M. E. Reding, J. M. Frantz, J. C. Locke, and C. Krause. 2011. A rare excitatory amino acid from flowers of zonal geranium responsible for paralyzing the Japanese beetle. *Proceedings of the National Academy of Sciences*.

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