Giant willow aphid, *Tuberolachnus salignus* (Gmelin) (Hemiptera:Aphididae) : Biology, nature of damage and management

Aryan Bhandari, SC Verma, PL Sharma, RS Chandel, VGS Chandel, Nikita Chauhan, Vibhuti Sharma, Lalit Kalia, Chander Singh, Anshuman Semwal and Pankaj Sharma

The giant willow aphid, *Tuberolachnus salignus* (Gmelin) (Hemiptera: Aphididae: Lachninae), is a cosmopolitan pest that sucks sap from the stems of willow plants (*Salix* spp.) and has also been reported from poplar trees (*Populus* spp.) (Sopow et al., 2017). The origin of the giant willow aphid is considered to be Asia but has now spread to the regions where suitable hosts are present (Blackman and Eastop, 1994). This aphid spreads in spring, summer and autumn in its winged form whereas the wingless forms increase in spring and summer, peak in autumn and decrease in winter (Jones et al., 2021). When the infestation of giant willow aphids is high, a significant amount of honeydew can be witnessed on the affected branches of trees. They predominantly feed on stems and often appear in extensive colonies, covering over half of the bark surface (Collins et al., 2001). The infested tree can be observed from a distance due to conspicuous black-coloured sooty mould on twigs, branches and trunk of the tree. Although, this aphid is considered a major pest of willow, a forest tree, there have been records where it has been observed in fruit crops like apple and quince (Le Baron, 1972; Salisbury et al., 2022) which underscores its ability of being a potential pest to fruit crops.

Host range and distribution

Host range of giant willow aphid varies from forest trees like S*alix* spp. (*Populus* spp.) (Sopow et al., 2017) to fruit crops including apple and quince (Le Baron, 1972; Salisbury et al., 2022). Black Poplar tree (*Populus nigra* L.) and a shrub called *Coprosoma macrocarpa* was also recorded as its host (Charles et al., 2014; Sopow et al.,2017). Though the origin of giant willow aphid is Asia but it was also recorded in Auckland (New Zealand) on *Salix* × *fragilis* L. after which it was recorded in north and south islands of New Zealand (Gunawardana et al, 2014; Sopow et al., 2014). It was also recorded from Australia in early 2014 in New South Wales by State Government Victoria Department of Environment and Primary Industries. In India, the giant willow aphid was recorded on *Salix tetrasperma*, *Salix viminalis* and *Salix alba* in Karnataka, Spiti valley and Ladakh, respectively (Joshi, 1980; Sharma and Thakur; 1993; Hussain et al., 2021).

Nature of damage

Giant willow aphids have specialized mouthparts for piercing and sucking, particularly the stylet, consisting of food and salivary canal. This insect, known for its sap-sucking behaviour, forms colonies on the tender stems and branches of host trees, mainly targeting the phloem for feeding. The extraction of sap by giant willow aphids primarily occurs from recently developed phloem sieve tubes in proximity to the cambium (Mittler, 1957).

Among the affected trees, the colonies of giant willow aphids can be observed on twigs, branches and even the trunk, particularly near the tree basin. When the colonies of this insect are brushed off, there is the presence of distinctive marks caused by their feeding on the tree branches. In areas of extensive aphid infestation, one can readily observe a continuous release of honeydew due to which there is

the development of characteristic black sooty mould on trees and basins of trees. Such infested trees can be observed from a distance due to their distinct black colouration. The honeydew oozing out of the affected trees attracts many honeydew-loving insects including bees and wasps. The buzzing sound of these insects around peach trees is an indicator of giant willow aphid infestation.

Morphology, biology and life cycle

T. salignus is a large, dark greyish to black coloured aphid having a size in the range of 5 to 5.8 mm (Blackman and Eastop, 1994). A distinctive feature of this aphid that differentiates it from other aphids is the presence of a greyish-golden abdomen with a characteristic black dorsal tubercle, measuring 0.2–0.3 mm in height, especially prominent in wingless adults. The antennae are shorter than the body. Winged forms have unpigmented forewing membranes with dark brown markings. A notable behaviour of the giant willow aphid colony is the collective lifting of hind legs while waving a hand over them (Hussain et al., 2021).

T. salignus reproduces parthenogenetically i.e. embryo development takes place without fertilization (Aradottir et al., 2012). The oviparous females, eggs and females are absent in *T. salignus* (Dhatwalia and Gautam, 2009). The colonies consist only of nymphs and adult parthenogenetic females. The nymphs undergo four developmental stages, with the youngest appearing light brown. As eggs are not produced, it is presumed that viviparous females overwinter and start emerging the following year (Aradottir et al., 2012). Martin (2017) suggested that the ability to overwinter is exclusive to the winged form, in contrast to Szelegiewicz (1962) who proposed that even younger nymphs can withstand winter conditions. Fang et al. (2016) observed aphids concealing themselves in the cracks of willow trunk bark, indicating a potential strategy for surviving harsh winter conditions. *T. salignus* has a mean generation time of 2–3 weeks when exposed to temperatures ranging between 17.5 and 22.5°C, with the most favourable development occurring at 20°C (Özder and Sağlam, 2008).

Uses of honeydew of giant willow aphid

Honeydew secreted by giant willow aphids has been utilized for various purposes in different regions of the world, for example, in the indigenous tribal community of Spiti Valley of Himachal Pradesh honeydew is collected and skillfully utilized to prepare a sweet delicacy known as Dungsee (Sharma et al., 1995) whereas, in some region of the world, it has been used as a dyeing agent for military uniforms (Charles et al. 2014). The secretion of honeydew from the giant willow aphid leads to an elevation in the C: N ratio in the affected soil (Tun et al., 2020). The honeydew contains a trisaccharide called melezitose which resists breakdown upon hydrolysis. Therefore, it acts as a potential prebiotic that supports the growth of beneficial gut bacteria in the human digestive system (Swears and Manley-Harris, 2021).

Management

There can be many management alternatives to control giant willow aphids but biological control is most appropriate since it is eco-friendly and carries low risks to ecosystems in contrast to chemical pesticides. Biological control agents, like natural predators or parasites, focus on specific pests without causing harm to other non-target organisms. Additionally, it diminishes reliance on synthetic chemicals, which may adversely affect human health, wildlife and the environment. Biological control methods present a more sustainable and ecologically harmonious strategy for handling aphid populations. Furthermore, biological control tends to be self-sustaining, as natural predators and parasites can establish and sustain themselves in the ecosystem, ensuring prolonged control without the necessity for repeated pesticide applications.

The coccinellid predator, *Harmonia axyridis* Pallas was identified as a potential predator of giant willow aphid in New Zealand (Sopow et al.,

2017). Nevertheless, the efficacy of *H. axyridis* as a biocontrol agent remained uncertain, as it was unclear whether the aphid served as a preferred food source and supported the predator's development and reproduction. Other coccinellid predators like *Adalia bipunctata* L., *Coccinella undecimpunctata* L. and *Harmonia conformis* (Boisduval) has also been recorded on this aphid as a generalist predator. In Israel, a predatory midge, *Aphidoletes aphidimyza* (Rondani) was recorded on the colonies of this aphid. The parasitoid, *Pauesia nigrovaria* Provancher has proven to be highly effective, attributed to its specificity towards hosts and minimal associated risks (Sopow et al., 2021). Another parasitoid *Pauesia salignae* Watanabe is exclusively recorded on giant willow aphid and has been observed in various regions, including India, Japan, Korea, Taiwan, and the United States. *Dendrocerus carpentri* (Curtis) and *D. ramicornis* (Boheman) are the two hyperparasitoids recorded on giant willow aphids out of which *D. carpentri* was recorded in New Zealand (Takada, 1973; Walker and Cameron, 1981). However, their field efficacy has still not been explored. *Neozygites turbinatus* (R.G. Kenneth) Remaud and Keller, identified as the fungal parasite of giant willow aphid, have been recorded in Europe and Israel (Keller, 1997). Particularly during giant willow outbreaks in willow plantations, a significant infestation of willow aphids by this fungus has been observed. Barta and Cagáň (2006) conducted research indicating that this infestation has the potential to lead to the destruction of the aphid population.

The utilization of insecticides to combat giant willow aphid-infested trees is considered unsuitable for widespread or prolonged control due to the potential harm it poses to non-target bees. However, chemical control might be deemed a viable short-term solution in specific locations where an elevated presence of wasps attracted to honeydew poses a risk to human health, such as instances of stinging incidents (Sopow et al., 2017). Additionally, targeted methods can be employed to safely manage wasps, regardless of aphid populations.

Conclusion

The giant willow aphid, *T. salignus*, represents a significant challenge for both natural and horticultural systems due to its widespread distribution and ability to infest a variety of hosts, including willow trees and fruit crops. Its impact on affected trees is multifaceted, ranging from direct damage through sap-sucking to indirect effects such as the production of honeydew and the growth of sooty mould. Understanding the biology and life cycle of the giant willow aphid is crucial for implementing effective management strategies. While chemical control methods exist, they pose risks to non-target organisms and are not considered sustainable in the long term. Biological control methods, on the other hand, offer a more eco-friendly and sustainable approach, utilizing natural predators and parasites to regulate aphid populations. Research into the economic importance of giant willow aphid honeydew has revealed its potential utility in various applications, including as a drink, a dyeing agent, and even as a prebiotic. However, its impact on affected trees and ecosystems must be carefully managed to prevent widespread damage. In conclusion, addressing the challenges posed by the giant willow aphid requires a comprehensive approach that integrates biological, chemical, and cultural control methods while considering the economic and ecological implications of each strategy. By doing so, we can strive towards sustainable management practices that mitigate the impact of this cosmopolitan pest on both natural and agricultural environments.

References

Aradottir G I, Hanley S J, Collins C M, Dawson K J, Karp A, Leather S R, Shield I, Harrington R. 2012. Population genetics of *Tuberolachnus salignus*, an obligate parthenogenetic aphid. *A*gricultural and Forest Entomology. 14(2): 197-205. doi: 10.1111/j.1461-9563.2011.00559.x.

Barta M, Cagáň L U. 2006. Observations on the occurrence of Entomophthorales infecting aphids (Aphidoidea) in

Slovakia. BioControl. 51:795-808.

Blackman R L , Eastop V F. 1994. *Aphids on the world's trees: an identification and information guide*. CAB International. Wallingford, Oxon, UK. 987p.

Charles J G, Nef L, Allegro G, Collins C M, Delplanque A, Gimenez R S, Höglund S, Jiafu H, Larsson S, Luo Y, Parra P, Singh A P, Volney W J A, Augustin S. 2014. Insect and other pests of poplars and willows. In Poplars and willows: trees for society and the environment. Wallingford UK: CABI. pp 459-526.

Collins C M, Rosado R G, Leather S R. 2001. The impact of the aphids *Tuberolachnus salignus* and *Pterocomma salicis* on willow trees. Annals of Applied Biology. 138(2):133-140.

Dhatwalia N, Gautam D C. 2009. Cytogenetic studies on willow aphids. Cytologia. 74 (2): 125-131.

Fang F, Chen J, Jiang L Y, Chen R, Qiao G X. 2017. Biological traits yield divergent phylogeographical patterns between two aphids living on the same host plants. Journal of Biogeography. *44*(2): 348-360.

Gunawardana D A, Flynn H, Pearson, Sopow S. 2014. Giant willow aphid: a new aphid on willows in New Zealand. Surveillance. 41:29–30.

Hussain B, War A R, Singh S, Ahmad S. 2021. First Record of an Invasive Pest, Giant Willow Aphid, *Tuberolachnus salignus* (Gmelin) (Hemiptera: Aphididae) on *Salix alba* in the Cold Arid Region of Ladakh, India. Entomological News. 129. doi: 10.3157/021.129.0508.

Jones T G, Min Tun K, Minor M and Clavijo McCormick A. 2021. The giant willow aphid (*Tuberolachnus salignus*) and its effects on the survival and growth of willows. *A*gricultural and Forest Entomology. 23(4): 420-428.

Joshi S. 1980. Aphids (Homoptera: Aphididae) and their hosts from Karnataka, India. Biosystematica. 2(1):19-32.

Keller S. 1997. The genus *Neozygites* (Zygomycetes, Entomophthorales) with special reference to species found in tropical regions. Sydowia. 49(2):118-146.

Le Baron W. 1972. Insects injurious to the willow. Report of the State Entomologist (Illinois). 2: 138-139.

Martin N A. 2017. Giant willow aphid - *Tuberolachnus salignus*. http://nzacfactsheets.landcareresearch.co.nz/factsheet/InterestingInsects/Giant-willow-aphid---Tuberolachnus-salignus.html (Accessed on 28 March 2024 at 03:45 PM).

Mittler T E. 1957. Studies on the feeding and nutrition of *Tuberolachnus salignus* (Gmelin) (Homoptera, Aphididae): 1. The uptake of phloem sap. Journal of Experimental Biology. 34(3): 334-341.

Özder N, Sağlam Ö. 2008. Effect of temperature on the biology of *Tuberolachnus salignus* (Gmelin) (Sternorrhyncha: Aphididae) on (*Salix alba*). *Journal of Central European Agriculture*. 9(1): 155-160.

Salisbury A, Mansfield L, Edwards G, Aradottir GI. 2022. Quince (*Cydonia oblanga* Mill), an unusual host for the giant willow aphid *Tuberolachnus salignus* Gmelin (Hemiptera: Aphididae). British Journal of Entomology and Natural History. 35 (4): 416-418.

Sharma G C and Thakur J R. 1993. Biology of

giant willow aphid, *Tuberolachnus salignus* (Gmelin) (Homoptera: Aphididae) in cold arid zone of HP. Indian Forest. 199 (8): 648-653.

Sharma G C, Thakur J R, Kashyap A S, Joshi VK. 1995. Giant willow aphid *Tuberolachnus salignus* (Gmelin), a producer of nutritious honey food in dry temperature zone of Himachal Pradesh. Insect Science. 8 (1): 110-111.

Sopow S, Gresham B, Gunawardana D, Flynn A. 2014. *Tuberolachnus salignus*, a new aphid on the block. Forest Health News. 246:1–2.

Sopow SL, Jones T, McIvor I, McLean JA and Pawson SM. 2017. Potential impacts of *Tuberolachnus salignus* (giant willow aphid) in New Zealand and options for control. Agricultural and Forest Entomology. 19(3): 225-234.

Swears R M and Manley-Harris M. 2021. Composition and potential as a prebiotic functional food of a Giant Willow Aphid (*Tuberolachnus salignus*) honeydew honey produced in New Zealand. Food Chemistry. 345: 128662.

Szelegiewicz H. 1962. Materiały do poznania fauny mszyc (Homoptera, Aphididae) Polski. I. Podrodzina Lachninae. Fragmenta faunistica. 6: 63-96.

Takada H. 1973. Studies on aphid hyperparasites of Japan, 1-aphid hyperparasites of the genus *Dendrocerus ratzeburg* occurring in Japan (Hymenoptera: Ceraphronidae). *Insecta Matsumurana. New series: Journal of the* Faculty of Agriculture Hokkaido University, Series Entomology. 2: 1-37.

Tun KM, McCormick AC, Jones T, Garbuz S and Minor M. 2020. Honeydew deposition by the giant willow aphid (*Tuberolachnus salignus*) affects soil biota and soil biochemical properties. Insects. 11(8): 460.

Walker G P, Cameron P J. 1981. The biology of *Dendrocerus carpenteri* (Hymenoptera: Ceraphronidae), a parasite of *Aphidius* species, and field observations of *Dendrocerus* species as hyperparasites of *Acyrthosiphon* species. New Zealand Journal of Zoology. 8(4): 531-538.

AUTHORS

Aryan Bhandari*, S. C. Verma, P. L. Sharma, R. S. Chandel, V. G. S. Chandel, Nikita Chauhan, Vibhuti Sharma, Lalit Kalia, Chander Singh, Anshuman Semwal and Pankaj Sharma

Dr. Yashwant Singh Parmar University of Horticulture & Forestry, Solan, Himachal Pradesh – 173230

*E-mail: aryanbhandari1999@gmail.com