# Laboratory rearing of the woolly aphid, *Eriosoma lanigerum* (Hausmann) (Hemiptera: Aphididae).

**S. K. Asante** and **W. Danthanarayana**, Department of Zoology, University of New England, Armidale, N.S.W., 2351, Australia.

## Summary

**A procedure for establishing a laboratory colony of woolly aphid, *Eriosoma lanigerum*, is described. It involves rearing of the aphid on twigs removed from mature apple trees and placed in jars of water. This simple and economically inexpensive method was developed to allow year-round rearing of large numbers of genetically-related insects for laboratory bioassays and also to permit practical experimentation under varying environmental conditions.**

## Introduction

Woolly aphid, *Eriosoma lanigerum* (Hausmann) is a widely distributed and important apple pest. A native of North America (Baker 1915), it is believed to have reached Australia in 1846 (Nicholls 1919). Both the nymphs and adults damage roots and shoots of apple trees and some ornamental shrubs. Despite its early record and economic importance, very little information is available on its biology and ecology in Australia (Nicholls 1919, Lower 1968, Hely *et al.* 1982, Thwaite and Bower 1983). Because of recent interest in the population dynamics of woolly aphid (Weber and Brown 1988, the present study) a convenient and efficient rearing method has become essential for laboratory studies on its biology and ecology (e.g., determination of physiological time scale for development).

Some authors have used the roots of potted apple seedlings (Lohrenz 1911); seedling apple in jars of water (Marcovitch 1934); cut calloused roots in moist sand (Schoene and Underhill 1935); potted seedling apple (Hoyt and Madsen 1960, Gautam and Verma 1983) to maintain cultures of woolly aphid in the laboratory. Some of these methods are economically expensive and are not suitable for observations on nymphal development and adult reproductive behaviour under different environmental conditions (e.g., constant temperature and/or humidity). A less expensive technique for maintaining laboratory colonies of woolly aphid was therefore developed. This rearing procedure is suitable for biological studies in growth cabinets and hence useful for the estimation of the demographic parameters of this insect.

## Materials and Methods

Pieces of twigs of about 25 - 30 cm long and 1 - 1.5 cm diameter were cut from mature apple trees. The bark and part of the wood about 5 cm × 1.5 cm was removed from the upper part of the twigs. Ten apterous parthenogenetic adults were placed on each damaged portion and were confined within sleeve cages (Figure 1). The main component of the cage is a modified 8 cm high by 2 cm diameter transparent plastic vial. The base of the vial was removed and a side hole 4 cm long × 7 cm wide for ventilation was cut. A sleeve of a white-coloured 100% polyester organza was glued with contact adhesive to the side hole. Two pieces of white polyester organza each about 10 cm × 6.5 cm were cut and a piece was glued around each opening at the opposite ends of the vial such that one end of the organza overlapped the other. The overlapping ends were glued together to form a sleeve around the opening. The twig, with the aphids, was pushed through one end of the sleeve into the plastic cylinder so that the aphids reached to about the middle of the cage. The two ends of the sleeve were then tied with a cotton tread to keep the cage in position (Figure 1). Each unit was placed in a jar 12 cm high and 5.5 cm in diameter containing about three-quarters full of water. The jars were kept at room temperature of 15 - 28°C (mean 21°C) and relative humidity of 40 - 75%. A colony could survive on such a twig for 40 - 68 days.

To determine the duration of each instar, a single apterous parthenogenetic adult was placed on a twig and caged as described above. When the first young were produced, the adult female and excess nymphs were removed and the remaining nymph was observed daily. The fecundity and longevity of individuals were determined by setting up similar cages each containing one adult female. In addition, the size (length and width) of the different instars were measured with an ocular micrometer.

## Results and Discussion

The duration of each instar period, adult longevity, fecundity and mean size of each instar studied under the above rearing technique are similar to those of others (Tables 1, 2 and 3). Apterous parthenogenetic females of the woolly aphid undergo four moults resulting in five instar stages. Except for the first instar,

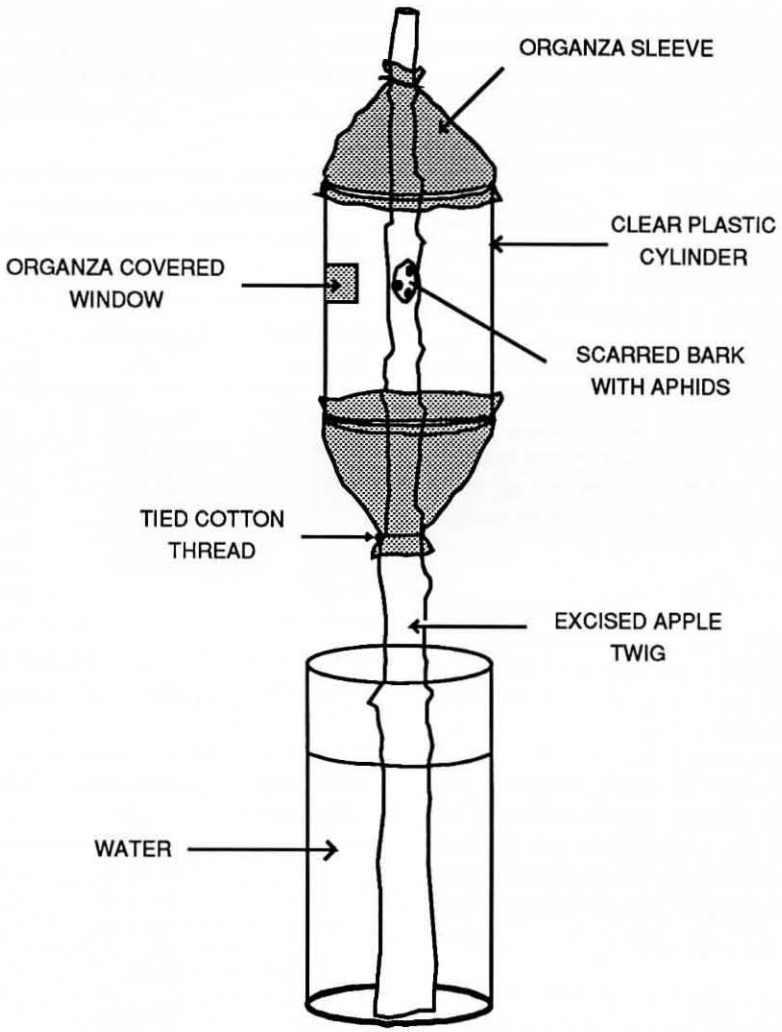


**Figure 1. Diagrammatic representation of the method of laboratory rearing.**

**Table 1. Duration of developmental stages, longevity and fecundity of apterous parthenogenetic females of woolly aphid reared on apple twigs at a mean temperature of 21°C.**

| | Nymphal Period (in days) | | | | Total Nymphal Period (in days) | Adult Life (in days) | Total Life (in days) | Progeny Produced by a female | Reproductive Period (in days) |
|---|---|---|---|---|---|---|---|---|---|
| | First Instar | Second Instar | Third Instar | Fourth Instar | | | | | |
| Range | 4-14 | 2-5 | 1-5 | 1-5 | 10-25 | 16-27 | 31-49 | 79-134 | 15-22 |
| Mean ±SE | 8.35 ±0.351 | 3.28 ±0.15 | 2.65 ±0.15 | 3.07 ±0.16 | 17.39 ±0.59 | 21.00 ±1.27 | 42.20 ±1.87 | 98.00 ±5.37 | 19.00 |
| Number Observed | 55 | 47 | 46 | 44 | 44 | 33 | 33 | 20 | 20 |

**Table 2. Comparison of the biology of apterous parthenogenetic females of woolly aphid reared by the various researchers.**

| Author | Year | Locality | Method | Total developmental Period (Days)* | Progeny per female | Reproductive Period (Days) | Total Life (Days) | Mean Length of Adult (mm) |
|---|---|---|---|---|---|---|---|---|
| Monzen | 1926 | Japan | Potted Seedling | 14.3 | 118.4 | 15.6 | 31.6 | - |
| Hori | 1930 | Japan | Potted Seedling | - | 70-100 | 7-21 | 22-52 | - |
| Nakayama *et al.* | 1928 | Korea | Potted Seedling | 10-14 | 14-169 | - | 30 | - |
| Bonnemaison | 1965 | France | Potted Seedling | - | 120-130 | - | - | - |
| Brittain | 1915 | Nova Scotia | Potted Seedling | 24.5 | - | - | - | - |
| Hely *et al.* | 1982 | Australia | Potted Seedling | 8-20 | 100 | - | - | - |
| Gautam & Verma | 1983 | India | Potted Seedling | 11.5-13 | 24-95 | 9-25 | 24-37.5 | - |
| Marcovitch | 1934 | USA | Seedling in water | - | 119 | 18.5 | - | - |
| Cottier | 1953 | New Zealand | Cultivated apple tree | - | - | - | - | 1.2-2.6 |
| Present Study** | 1989 | Australia | Excised twig in water | 10-25 | 79-134(98) | 15-22(19) | 31-49(42) | 1.54-2.62 |

* The data of other authors were obtained between 20 - 25°C.
** Means are in parentheses.

the mean durations of the instar periods at a mean temperature of 21°C (Table 1) closely approximated those reported for woolly aphid reared on potted seedling apple (Table 2). The longer first instar period recorded in the present study may be associated with the initial wandering behaviour of the nymphs after birth which may last for about one to two days prior to settlement. However, once feeding starts, the aphid remains stationary and feed continuously until the four moults have been completed. The mean number of nymphs produced per female was 98 over a reproductive period of 19 days (Table 1). The pre-reproductive and post-reproductive periods were 0.6 - 1.0 days and 1.0 - 8.0 days (Mean: 4.0 days) respectively. Gautam and Verma (1983) observed a post-reproductive life of 1 - 4 days at a mean temperature of 24.24°C. The present study also shows that adult longevity is 21 ± 1.27 days with a total life span of 42 days (Table 1).

Alate (winged), parthenogenetic and viviparous individuals occurred in the laboratory culture from late January-September, 1989. In the field (apple orchard) they were found from late January-May with maximum population in March-April.

**Table 3. Measurements of developmental stages of woolly aphid reared on excised apple twigs.**

| Stage | Number Observed | Length (mm)[b] Range | Length (mm)[b] Mean ± S.E. | Width (mm)[a] Range | Width (mm)[a] Mean ± S.E. |
|---|---|---|---|---|---|
| 1st Instar | 60 | 0.538-0.769 | 0.637±0.007 | 0.231-0.346 | 0.282± 0.003 |
| 2nd Instar | 40 | 0.731-1.192 | 0.989±0.016 | 0.346-0.577 | 0.496±0.010 |
| 3rd Instar | 42 | 1.000-1.538 | 1.293±0.019 | 0.538-0.808 | 0.930±0.009 |
| 4th Instar | 35 | 1.538-2.000 | 1.764±0.021 | 0.846-1.038 | 0.930±0.011 |
| Adult* | 50 | 1.538-2.615 | 2.210±0.033 | 1.000-1.500 | 1.290±0.018 |

[a] Measurements of width were of the widest portions of the abdomen.
* Adult apterous parthenogenetic females.
[b] Measurements of length were from tip of head to end of cauda.

The mean length of adult alate measured from tip of head to end of cauda was 2.07 ± 0.2 mm (1.77 - 2.54 mm) and 0.92 ± 0.01 mm (0.77 - 1.12 mm) wide where broadest (n = 50). They live for about 3 - 6 days (mean 4.67 ± 0.48 days). Their progeny were mainly sexuales (males and oviparae), apterous and with degenerate (atrophied) mouthparts. The number of sexuales produced per adult alata averaged 6.88 ± 0.34 (range 2 - 11 nymphs; n = 72). Gautam and Verma (1983) observed that adult alata individuals live for 4 - 7 days (mean 5.4 days) and the progeny produced ranges from 4 to 8 sexuales (average 5.3 nymphs). However, it was found that some alate individuals could give birth to a mixture of sexuales and nymphs with fully developed mouthparts like the progeny of apterous parthenogenetic females. These long-beaked progeny moulted four times and reproduced parthenogenetically when fed on apple twig. Fluiter (1931)

reported that in Holland the adult alate of woolly aphid may also reproduce. Apart from normal males and oviparae (females), intermediates with fully developed mouthparts like those of viviparae or with half developed mouthparts are produced. Schoene and Underhill (1935) made a similar observation in Virginia (U.S.A.).

The female (ovipara) measured on the average 0.93 ± 0.01 mm (0.76 - 1.02 mm) long and 0.50 ± 0.01 mm (0.42 - 0.58 mm) wide (n = 22). The male is smaller in size than the female with an average length of 0.70 ± 0.01 mm (0.54 - 0.81 mm) and 0.30 ± 0.01 mm (0.27 - 0.33 mm) wide (n = 22). The ratio of males to oviparae was 1 : 1.69. Schoene and Underhill (1935) observed twice as many females as males, whilst Lohrenz (1911) reported three times more males than females.

The present observations are comparable to those of other authors who cultured the woolly aphid on apple seedlings (Table 2). Therefore the excised apple twigs seem to contain adequate nutrients for growth, development, reproduction and survival of one generation. This rearing procedure is being used for life-cycle studies, the determination of degree-day requirement for development and the effects of host plant condition, photoperiod and temperature on the development of polymorphism in this species.

*Acknowledgements*

Financial support was provided by AIDAB and U.N.E. Internal Research Grants. Thanks are expressed to W. Higgins, Z. Enoch, S. Gillett and S. Hamdorf for technical assistance. S. Higgins typed the manuscript.

**References**

Baker, A.C. (1915). The woolly apple aphis. United States Department of Agriculture Entomology Report 101, 1-55.

Bonnemaison, L. (1965). Observations écologiques sur *Aphelinus mali* Haldeman parasite due puceron lanigère *(Eriosoma lanigerum* Hausmann). *Annales Societe Entomologie France*, 1, No. 1, pp. 143-176.

Brittain, W.H. (1915). Some Hemiptera attacking the apple. Proceedings of the Entomological Society of Nova Scotia. No. 1, pp. 33-36.

Cottier, W. (1953). Aphids of New Zealand. Bulletin of the New Zealand Department of Scientific and Industrial Research 106., pp. 332-336.

Fluiter, H. J. de (1931). De bloedluis *Eriosoma lanigerum* (Hausm.) in Nederland (The woolly aphis in Holland). (Proefschrift University Leiden.) VIII plus 126 pp. Wageningen. (Abstract in Review of Applied Entomology 20:2). Original not seen.

Gautam, D.C. and Verma, L.R. (1983). Seasonal biology and reproductive behaviour of woolly aphid (*Eriosoma lanigerum* Hausmann). *Indian Journal of Horticulture* 40, No. 2, 119-123.

Hely, P.C., Pasfield, G. and Gellatley, J.G. (1982). Woolly aphid, *Eriosoma lanigerum*. *In* 'Insect Pests of Fruits and Vegetables in N.S.W.', Inkata Press 312 pp.

Hori, M. (1930). The Woolly Apple Aphis in Hokkaido, with special reference to its control. Report of the Hokkaido Agricultural Experimental Station No. 24, pp. 35-63.

Hoyt, S.C. and Madsen, H.F. (1960). Dispersal behaviour of the first instar nymphs of the woolly aphid. *Hilgarida* 30, 267-299.

Lohrenz, H.W. (1911). The woolly aphis, *Schizoneura lanigera*. *Journal of Economic Entomology* 4, 162-180.

Lower, H.F. (1968). Hard-to-kill pests of fruit trees - woolly aphid. *Journal of Agriculture, South Australia* 72, No. 1, pp. 14-15.

Marcovitch, S. (1934). The University of Tennessee Agricultural experiment station, Bulletin No. 151, 16 pp.

Monzen, K. (1926). The woolly apple aphis, *Eriosoma lanigerum* Hausmann in Japan with special reference to its life history and susceptibility of the host plant. International Entomological Congress. Zurich 2, 249-75.

Nakayama, S., Tanaka, T., and Maruta, S. (1928). The woolly apple aphis (*Eriosoma lanigerum* ) in Chosen. Bulletin of the Agricultural Experiment Station Government-General of Chosen, No. 4, 21 pp.

Nicholls, H.M. (1919). The Woolly Aphis (*Eriosoma lanigera* ). Agricultural and Stock Department Bulletin No. 83, 8 pp.

Schoene, W.H. and Underhill, G.W. (1935). Life history and migration of the apple woolly aphis. Virginia Agriculture Experiment Station Technical Bulletin 57, 1-31.

Thwaite, W.G. and Bower, C.C. (1983). Woolly Aphid. AGFACT H4.AE.3, 3 pp. Agricultural Research and Veterinary Centre, Orange, N.S.W., Australia.

Weber D.C. and Brown, M.W. (1988). Impact of woolly aphid (Homoptera: Aphididae) on the growth of potted apple trees. *Journal of Economic Entomology*, Vol. 81, No. 4, pp. 1170-1177.