APHID TRAPPING RECORDS IN NORTHERN SYDNEY FOR SPRING, SUMMER AND AUTUMN, 2020-21

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Summary

This paper reports on aphids caught in a yellow trap in the Sydney suburb of Beecroft for spring 2020 through to the end of autumn 2021. It is a continuation of observations previously reported for autumn-winter 2020 and compares data from the full year winter 2020 to autumn 2021 with data from collections made in the nearby suburb of Rydalmere in 1960-1. Season for season, over 65% of the aphid species found in 1960-1 were not found in 2020-1, but 30-50% of the catch was made up "new" species, mostly not recorded in Australia at the time of the earlier project. Biological characteristics of the missing species such as host range and annual cycle were examined, but no consistent trend was identified to account for their absence. It may result partly from stabilisation of low population sizes after initial explosions following introduction. Weather during the two collections was also examined. Whilst 2020-1 was generally warmer and had more hot days, the differences seemed unlikely to have caused the substantial loss of species. Events of heavy rainfall in 1961 and in 2021 were followed by loss of species. Extremes of weather occurred during 2019 and early 2020, with low rainfall, high temperatures, strong winds and extensive bushfires. These would inevitably have affected aphid populations. Other possible factors based on changes in the built environment are noted.

Key Words: aphids, survey, diversity, weather, annual cycles, host plants.

INTRODUCTION

Many aphids are serious pests in agriculture and horticulture, whether by direct or indirect damage (removing nutrients and water from plants, or injecting toxic saliva, or transmitting viruses). They may also have direct or indirect effects on livestock, by reducing growth of pasture or feed crops such as lucerne (Bishop *et al.* 1982, Ryalls *et al*. 2013), or by causing damage to the animals themselves or to their products. Examples of such damage are photosensitisation of sheep that have ingested cowpea aphid, *Aphis craccivora* Koch (Powells 2023) and damage to wool by honeydew excreted by the giant willow aphid, *Tuberolachnus salignus* (Gmelin) (Dominiak and Worsley 2018). *T. salignus* honeydew may also affect honey production: whilst it provides a source nutrients for bees, in some cases it cannot be successfully processed into commercial honey (Dominiak 2016).

The main means of aphid dispersal is by parthenogenetic production of winged individuals which undertake migratory flights, reviewed by Robert (1987), Loxdale and Lushai (1999), Hardie (1999) and discussed by Parry (2013). These flights are often relatively local (up to about 1 km) but with wind assistance may extend to hundreds of kilometres.

The UK's Rothamsted Insect Survey uses suction traps to capture aphids and has been running continuously for 50 years. It provides forecasts and warnings to farmers. Bell *et al.* (2014) analysed 50 years of aphid flight data with respect to climate and concluded that post-winter aphid flights commence earlier as the climate warms. Overall data for Australia is scanty, except for studies of pest aphids on crops such as lucerne, cereals or brassicas. The only inclusive broad scale surveys of aphid presence were conducted in Eastern Australia in 1960-2 by Hughes *et al*. (1964, 1965). Interestingly, these traps were set up largely to assist the work of Victor Eastop on the aphid fauna of Australia (Eastop 1966). Hughes *et al*. (1964) discussed the usefulness and the limitations of these traps in determining patterns of aphid occurrence in space or time. Surveys of this kind are useful in mapping the presence of particular species, and the annual flight patterns of some species. Absence of a species in a trap does not prove its absence in an area, but consistent absence of previously common species is indicative of change over time, and when field observations supplement trap catches, a clearer idea of absence of species can be formed. Changes in the diversity of aphids found in traps over time can be caused by environmental change, whether due to plant distribution or to climate.

Similar long-term surveys have not been conducted in Australia since those led by Hughes, and in the intervening time, the number of species of aphids known to occur in Australia increased from about 120 to about 170 in 1998 (Carver pers. comm.), and further species have arrived or been recognised since, making the current total over 200. An incomplete list of additions was given by Brumley (2020), but even since Brumley's paper, more species have been added, such as the crape myrtle aphid *Sarucallis kahawaluokalani* (Kirkaldy), first recorded from yellow trap collections (Hales and Gillespie 2020, Hales 2020) and *Aphis lugentis* Williams from *Senecio* (Petit *et al*. 2022). I made daily collections from yellow traps in Beecroft NSW from mid-April 2020 to the end of May 2023. Data from autumn and winter 2020 have been reported (Hales 2020), showing that species found commonly by Hughes *et al.* (1964) were often absent from the 2020 collections, while species that have arrived since that survey were present in the traps (Hales 2020). The current paper provides data for the succeeding nine months, and thus, with the winter data reported in Hales (2020), covers four complete consecutive seasons. Other aphid species were observed in the field, but the data presented are restricted to those identified from the yellow trap. The data from 2022-3 will be presented separately. Possible explanations for the changes from the collections at Rydalmere in 1961 are considered.

MATERIALS AND METHODS

The methods were as described previously (Hales 2020), with aphids being collected daily from a yellow tray filled with water and a small amount of detergent. Aphids that could not be identified from initial observations were preserved in 80% ethanol, slide-mounted as described (Hales 2020) and identified by the author. I recorded various parameters including the number of rhinaria on antennal segments 3 and 4, the lengths of the processus terminalis and base of antennal segment 6 (or 5 for 5-segmented antennae) and ratio between these two measurements, the total length of the antenna, the colour, shape and length of the siphunculi, the colour, shape and length of the cauda, the ratio of siphuncular length to caudal length, the shape of the antennal tubercles, the number of hairs on the cauda, the pigmentation pattern on the abdomen, the distribution of abdominal tubercles, the body length, the ratio of body length to siphuncular length, and for some specimens, the first tarsal chaetotaxy, the length of the last rostral segment, the length of hind tarsal segment 2, and the ratio of the last rostral segment to the length of hind tarsal segment 2. Other features were measured where necessary for distinguishing between congeneric species. Using this information, it was usually possible to determine the probable genus and sometimes species, using keys in Eastop (1966) and a punch card key based on this source. These determinations were supplemented by knowledge of more recent arrivals and illustrations of these and/or descriptions or keys to the genera and species involved. The slides remain in the author's collection as the work is continuing.

General field observations on host plants were made frequently, and special attention was paid to plants known as hosts for previously common species, e.g. on grasses, hibiscus, roses, citrus, hedge plants, oleanders/milkweeds. Weather data for 2020-21was derived from the Bureau of Meteorology website. Local weather stations such as North Parramatta were not operating in the early 1960s, so for comparative purposes, weather data for all relevant years at Sydney Airport (Station 066037) was used.

RESULTS

Numbers of individuals of each species trapped each month are shown in Tables 1 and 2, with each count representing a period of about half a month. They are recorded in order of first capture as in the Autumn - Winter data of Table 3 in Hales (2020), with additional species at the end of each table. For full listings of aphids in the Rydalmere collections of 1961 and 1962 see Hughes *et al*. (1964, monthly data, Table 6; 1965, Table 2, total catch for 1962).

Aphid species captured

Thirty two species of aphids were caught in the yellow trap during the period September 2020 to the end of May 2021 inclusive (Tables 1, 2). Table 3 of Hales (2020) includes data for winter 2020 (Hales 2020). All species below *Aulacorthum solani* (Kaltenbach) in Table 1 and 2 (below) of this paper were absent from the previous Autumn-Winter collections detailed in Hales (2020, Table 3).

Table 1. Species and numbers of aphids collected in a yellow trap in Beecroft NSW, September 2020 to February 2021 inclusive. Letters A-L indicate approximately half-month periods from the beginning of September to the end of February (Spring A-F), (Summer G-L).

Species	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Sarucallis kahawaluokalani	0	0	0	0	0	0	0	0	4	53	169	26
Hyperomyzus lactucae	0	0	0	3	0	0	0	0	3	0	3	2
Aphis spiraecola	20	18	21	102	161	24	3	5	1	15	2	1
Aphis citricidus	0	0	0	0	0	0	0	0	2	0	0	0
Macrosiphum euphorbiae	0	2	2	0	0	0	0	0	0	0	0	0
Shivaphis celti	1	3	2	1	0	1	0	0	0	0	col	0
Aphis gossypii	2	2	1	2	0	1	0	0	3	3	1	4
Tetraneura *	0	1	0	0	1	0	4	2	1	3	0	2
Takecallis arundinariae	0	0	0	0	0	1	0	0	0	0	0	0
Brachycaudus sp.	0	0	3	2	0	0	0	0	0	0	0	0
Megoura crassicauda	1	1	0	0	0	0	0	0	0	0	0	0
Aulacorthum solani	1	2	0	3	0	0	0	0	0	0	0	0
Aphis hederae	3	4	0	0	0	0	0	0	0	0	0	0
Periphyllus californiensis	0	53	62	0	0	0	0	0	0	0	0	0
Uroleucon sonchi	0	3	3	2	2	0	0	0	0	0	0	0
Uroleucon erigeronense	0	0	1	1	0	0	0	0	0	0	0	0
Tuberculatus annulatus	0	1	1	2	0	0	0	0	0	0	2	1
Brevicoryne brassicae	0	0	0	1	1	1	0	0	0	0	0	0
Dysaphis apiifolia	0	0	0	1	0	0	0	0	0	0	0	0
Dysaphis aucupariae	0	0	0	1	0	1	0	0	0	0	0	0
Aphis aurantia	0	0	0	1	0	0	0	2	col	0	0	1
Aphis craccivora	0	0	0	1	1	0	0	0	0	0	0	0
Dysaphis lappae	0	0	0	0	1	0	0	0	0	0	0	0
Brachycaudus helichrysi	0	0	0	0	0	1	0	0	0	0	0	0
Acyrthosiphon kondoi	0	0	0	0	0	1	0	0	0	1	1	0
Rhopalosiphum rufiabdominale	0	0	0	0	0	0	1	0	0	0	0	0

*The taxonomy of *Tetraneura* in Australia is confused. In the previous paper in this series, the species collected was referred to as *T. fusiformis* (Hales 2020) and Hughes (1964) recorded it as *T. hirsuta*, recorded by Eastop as *T. nigriabdominalis*. A recent review of the *Tetraneura akinire* group has tentatively recognised *T. nigriabdominalis* and *T. fusiformis* both as synonyms of *T. akinire* (Watanabe *et al.* 2022).

Table 2. Species and numbers of aphids collected in a yellow trap in Beecroft NSW, March 2021 to May 2021 inclusive (Autumn). Letters A-F indicate approximately half-month periods from the beginning of March to the end of May. m=males

Species	**A**	**B***	**C****	**D**	**E**	**F**
Sarucallis kahawaluokalani	11	10	3+1m	16	54+9m	20+9m
Hyperomyzus lactucae	2	0	0	1	6	0
Aphis spiraecola	4	0	0	7	20	11
Shivaphis celti	3	0	0	0	2	3
Aphis gossypii	5	0	0	2	9	7
Tetraneura	4	0	0	0	2	0
Brachycaudus sp.	0	0	0	0	0	3m?
Megoura crassicauda	1	0	0	1	0	0
Aulacorthum solani	1	0	0	1	7	0
Uroleucon sonchi	0	0	0	0	0	1
Uroleucon erigeronense	0	0	0	1	0	2
Tuberculatus annulatus	0	0	0	2	0	0
Aphis aurantia	1	1	0	1	1	0
Brachycaudus helichrysi	0	0	0	1	0	0
Metopolophium dirhodum	0	0	0	1	1	0
Macrosiphoniella sanborni	1	0	0	0	0	0
Tuberolachnus salignus	0	0	0	0	1	0
Myzus persicae	0	0	0	0	3	2
Tinocallis ulmiparvifoliae	0	0	0	1	4	2
Eucarazzia elegans	0	0	0	0	1	0

*Heavy rain for the first half of this period. ** No collections 1-8 April.

As in the Autumn-Winter catches for 2020, many species collected in 1961 were missing from the current Spring - Autumn collections. Table 3 divides the 2020-21 catch into "old" and "new" aphids on a season-by-season basis. "New" species are those not known from Australia prior to 1966 (Eastop 1966), or known but not collected in 1960-1. The absence of so many species is striking. Some of these were common in the Rydalmere collections, e.g. *Capitophorus eleagni* (Del Guercio), *Cavariella aegopodii* (Scopoli), *Lipaphis pseudobrassicae* (Davis) (as *L. erysimi*), *Rhopalosiphum maidis* (Fitch). The latter two have a broad host range. Conversely, *Aphis spiraecola* Patch, in small numbers in the Rydalmere collections of 1960-1, was the most commonly caught aphid in 2020-1, and the reverse was true for the polyphagous *Aphis gossypii* Glover, which was common in 1961 but relatively rare in 2020-1. It was shown by Freoa *et al*. (2023) that having more body pigmentation causes insects (*Drosophila*) to have a higher body temperature, in the same conditions, than do lighter coloured ones. This could be an explanation for the low numbers of the dark coloured *A. gossypii.* Table 4 summarises the numerical species composition of the 1960-1 and 2020-1 catches and shows the proportions of "new" and "old" aphids in the 2020-21 collections. Biological characteristics of the "missing" 28 aphid species were assembled (data from Eastop 1966) and those of the "new" aphids are shown in Table 5 (data mainly from Blackman and Eastop, *Aphids on the World's Plants* website).

Weather Comparisons

Maximum monthly temperatures and rainfall data for 1960-1 and 2020-1 are shown in Table 6. The year 2020 commenced with Australia's most severe bushfire season and with frequent days in summer, autumn and spring having temperatures well above average. In the whole of 1961-2 only 14 days exceeded 30 °C (Sydney Airport) and only one day in each year exceeded 35 °C. In 2020, 26 days exceeded 30 °C, including 9 days in the spring period covered in this paper, and 9 exceeded 35 °C, three of them in November. December, however, was relatively cool, as was the rest of summer (January and February 2021), with higher than average rainfall in the Sydney area, in contrast to very low rainfalls during 1961-2.

Table 3. Species caught by season in 2020-21. "Old" species (recorded in Australia by Eastop, 1966) are marked ^. Eastop recorded *Aphis aurantii* and *Periphyllus californiensis* (marked #) as present in Australia but they were not caught in Rydalmere in 1961. Hence they are regarded as "new".

Winter	**Spring**	**Summer**	**Autumn**
Aphis spiraecola^	*Acyrthosiphon kondoi*	*Acyrthosiphon kondoi*	*Aphis aurantii*#
Aulacorthum solani^	*Aphis aurantii*#	*Aphis aurantii*#	*Aphis gossypii*^
Brachycaudus sp.	*Aphis craccivora*^	*Aphis citricidus*^	*Aphis spiraecola*^
Megoura crassicauda	*Aphis gossypii*^	*Aphis gossypii*^	*Aulacorthum solani*^
Rhopalosiphum padi^	*Aphis hederae*	*Aphis spiraecola*^	*Brachycaudus helichrysi*^
Shivaphis celti	*Aphis spiraecola*^	*Hyperomyzus lactucae*^	*Brachycaudus* sp.
Takecallis arundinariae	*Aulacorthum solani*^	*Rhopalosiphum rufiabdominale*^	*Eucarazzia elegans*
Tetraneura *^	*Brachycaudus helichrysi*^	*Sarucallis kahawaluokalani*	*Hyperomyzus lactucae*^
Tinocallis ulmiparvifoliae^	*Brachycaudus* sp.	*Tetraneura* *^	*Macrosiphoniella sanborni*^
	Brevicoryne brassicae^	*Tuberculatus annulatus*^	*Megoura crassicauda*
	Dysaphis apiifolia^		*Metopolophium dirhodum*
	Dysaphis aucupariae		*Myzus persicae*^
	Dysaphis lappae		*Sarucallis kahawaluokalani*
	Hyperomyzus lactucae^		*Shivaphis celti*
	Macrosiphum euphorbiae^		*Tetraneura**^
	Megoura crassicauda		*Tinocallis ulmiparvifoliae*
	Periphyllus californiensis#		*Tuberculatus annulatus*^
	Shivaphis celti		*Tuberolachnus salignus*
	Takecallis arundinariae		*Uroleucon erigeronense*
	Tetraneura *^		*Uroleucon sonchi*
	Tuberculatus annulatus^		
	Uroleucon erigeronense		
	Uroleucon sonchi		
8	22	10	19

^= "old" species, total 17

Unmarked = "New" species, total 16

Total full year = 32 excluding undetermined *Brachycaudus*

Total 1961 44 spp. Missing from current collection 27 old spp.

Table 4. Comparison of number and composition of species captured in Rydalmere in 1961 and 2020. "New" species are defined as in Table 3.

		Winter	Spring	Summer	Autumn
No. Species	Hughes 1961	23	35	22	29
	Hales 2020-21	8**	22	10	20
"New" species		3	11#	3#	9
Species in common		2	10	6	9
"New" species %		38	50	30	45
Species present in 1961, absent in 2020-21		21	25	16	20
1961 species absent in 2020-1 %		91	71	73	69

* Data December 1960-February 1961. ** Data in Hales (2020) # *Aphis aurantii* and *Periphyllus californiensis* present in Australia (Eastop 1966), but not recorded by Hughes at Rydalmere and counted here as new. *A. spiraecola*, *Tetraneura*, *Tinocallis* and *Aulacorthum* absent in winter 1961.

Table 5. Characteristics of "new" aphid species, not present in Australia in 1961-2 but collected in 2020-1. Data for *Periphyllus* and *Aphis aurantii* (as *Toxoptera*) are available from Eastop (1966)*. *See text

"New" aphids	**Geographic origin**	**Host range**	**Annual cycle***	**Seasons in 2020-1**
Uroleucon sonchi	Palaearctic	Narrow	Anhol	Spr Aut
Uroleucon erigeronense	N Am	Narrow	Hol mon ?anhol here	Spr
Sarucallis kahawaluokalani	east Asia	Narrow	Hol mon	Sum Aut
Shivaphis celti	As, now widespread	Narrow	Hol mon ? Anhol here	Spr Aut
Takecallis arundinariae	As	Narrow	Anhol	Spr
Dysaphis lappae	E- central Asia	Narrow	Hol mon ? Anhol here	Spr
Megoura crassicauda	east Asia	Narrow	Anhol	Spr
Aphis hederae	widespread ? Europe	Narrow	Hol mon ? Anhol here	Spr
Dysaphis aucupariae	E	Narrow	Hol-heteroecious, prob. anhol here	Spr
Acyrthosiphon kondoi	As, now widespread	Broad within family	Hol mon ? Anhol here	Spr Sum
Myzus Hemerocallis	east Asia	Narrow	not known	Aut (2020)
Metopolophium dirhodum	E	Broad within family	Hol heteteroecious ?anhol here	Aut
Tuberolachnus salignus	C	Narrow	Anhol	Aut
Eucarazzia elegans	Middle east, central As	Broad within family	Hol mon anhol?	Aut

Table 6. Comparison of weather parameters for 1960-1 and 2020-1. Data for Sydney Airport, Bureau of Meteorology. Note: the first full season in the 1960-1 collections was summer, and the first in 2020-1 was winter. The values for each month within the season are shown.

		Monthly maximum temperature °C	**Days >= 30 °C**	**Days >= 35 °C**	**Monthly mean temperature °C**	**Total rainfall mm**	**Days rain over 10 mm**
1960-1	summer	32.0, 41.4, 33.9	*2, 4, 4*	0, 1, 0	22.9, 25.8, 26.0	196.8, 67.6, 70.6	8, 1, 3
	autumn	33.2, 29.2, 24.2	2,0,0	0	25.6, 22.8, 19.3	55.1, 112.1, 26.2	2, 3, 1
	winter	20.3, 20.6, 20.9	0, 0, 0	0	17.5, 16.7, 16.8	53.6, 51.8, 180.8	2, 1, 6
	spring	30.7, 33.7, 30.7	*1, 2, 1*	0	19.6, 23.1, 23.5	49.6, 43.4, 396.1	1, 1, 9
2020-1	winter	23.7, 24.2, 26.8	0, 0, 0	0	18.5, 17.7, 19.4	80.2, 127.4, 65.4	1, 2, 2
	spring	33.3, 34.8, 43.0	*2, 2, 6*	0	23.0, 24.3, 26.7	31.0, 65.2, 41.8	0, 2, 1
	summer	34, 41.6, 35.2	*5, 10, 1*	*0, 2, 1*	*26.2, 27.6, 25.9*	74.8, 61.3, 120.4	2, 1, 4
	Autumn	33.1, 30.1, 26.5	4, 2, 0	0	24.9, 23.9, 20.6	353.2, 16.7, 89.4	8, 1, 3

DISCUSSION

Comparisons with the 1960-1 Rydalmere data of Hughes *et al*. (1964) are interesting. They detected 44 species compared with 32 in the 2020-21 study for trapping in four consecutive seasons. Only 14 species occurred in both the 1961 and 2020-21 collections. Among the absentees in the current collections are three species of rose aphids and several more from grasses. Few aphids have been observed on grasses in the present work. *Sitobion miscanthi* (Takahashi) and *Sitobion fragariae* (Walker), common in Sydney in the 1990s, have not been seen or trapped. Absence from the yellow trap does not mean absence from the area. Occasional specimens of *Rhopalosiphum* spp. were found on plants. *Hysteroneura setariae* (Thomas) was observed on grasses, but it was not trapped. The rose aphid *Macrosiphum rosae* (Linnaeus) was observed from time to time on rose shoots but not trapped. No other rose aphid species were seen. The most common aphids in the Rydalmere samples were *Aphis gossypii* with a monthly peak of 1153, *Macrosiphum euphorbiae* (Thomas), with a monthly peak of 168, *Lipaphis erysimi* (now *L. pseudobrassicae* Davis), with a peak of 121, *Aphis craccivora* with a peak of 68, *Hyperomyzus lactucae* (Linnaeus) with a peak of 56, and *Myzus persicae* (Sulzer), with a peak of 84. In contrast, the present Beecroft samples contained no specimens of *L. pseudobrassicae* and only small numbers of the other three previously common species. The aphids caught in Beecroft in the largest numbers were *A. spiraecola* (all seasons), *S. kahawaluokalani* (summer and autumn) and *Periphyllus californiensis* (Shinji) (discrete spring flight). It is surprising that no *P. californiensis* were caught in the spring of 1961 as they were probably present in Australia and the host plant, Japanese maple, is widely planted as an ornamental tree. Eastop (1966) recorded them as present in three states, NSW, SA and Tasmania. They were, however, collected in the Rydalmere traps in 1962.

To try to explain the absence of species that were present at Rydalmere in 1961-2, I considered various aspects of their biology: geographic origin, host plant range, and annual cycle (Table 4). Eastop (1966) reported the supposed geographic origins of aphid species present in Australia at that time. The aphids present in 1961-2 but absent from the 2020-21 data originated predominantly from Europe (12 species), whilst eight were regarded as already cosmopolitan, six as Asian, one North American, and one unknown (see also Blackman and Eastop, *Aphids on the World's Plants* website). Using data mainly from the latter source, I concluded that 20 species had narrow host ranges, and 8 broad host ranges, including species with a broad range within a single large family of plants. Clearly, a species with a narrow host range is vulnerable to changes in the availability of its host plant/s. Most of the missing species were able to reproduce by continuous parthenogenesis (anholocycly) or were holocyclic and monoecious (having an obligatory sexual phase during the year with egg diapause, but on a single host species, usually a tree). A few were obligately holocyclic and heteroecious, i.e. with a primary host on which the diapausing eggs are laid, and one or more secondary hosts to which aphids migrate in the spring. In Australia, it is common for aphid species from the Palaearctic to transition from holocyclic to anholocyclic reproduction, with both types of annual cycles occurring simultaneously for some time. A holocylic and heteroecious life cycle presents a double vulnerability, as either primary and secondary hosts could become unavailable. Anholocycly has its own risks, especially if the founder population was small with limited genetic diversity, as deleterious mutations accumulate. In summary, there is no clear-cut biological reason based on host requirements or annual cycle for the apparent loss of these species. Geographic origin in Europe, parts of Asia, and North America, might suggest adaptation to cooler climates and susceptibility to higher temperatures.

Fourteen species of aphids that have arrived in Australia since 1961 were trapped in the current collections, i.e. nearly a third of the catch was made up of "new" species. Table 5 shows the characteristics of the "new" aphids. In contrast to the missing aphids, only three came from Europe, while eight came from Asia, one from North America, one was considered cosmopolitan and one unspecified Palaearctic (Blackman and Eastop, *Aphids on the World's Plants* website). Nearly all are probably anholocyclic in Australia, and most have a narrow host range. *S. kahawaluokalani* is the exception, being holocyclic and monoecious.

Temperature and rainfall data for 1960-1 and 2020-1 are shown in Table 6, using data for Sydney Airport. Monthly maximum and mean temperatures were higher for every month except March (33.1 v. 33.2°C) in 2020-1 when compared with 1960-1. Summer 2020-1 had more hot days, and more days over 35 °C than 1960-1, and a longer run of hot days >= 30 °C (5 days in January compared with 3 in January 1961). Autumn and winter mean maximum daily temperatures for both data sets were similar and slightly above the mean for all years. Spring in 2021 was slightly above average in September and October with more hot days, but lower in November; in 1961, spring temperatures were close to the average for all years. January rainfall was similar for both data sets but the highest monthly total of 353.2 mm in March 2021 was about three times the mean for March in all years, all other months for 2020-1 having well below average rainfall. I conclude that the heavy rainfall in the third week of March 2021 reduced the numbers of aphids and consequently the numbers flying, giving very low catches for the rest of March. Rainfall in 1961 was well below average for every month except for April, August and November. A similar heavy rainfall event in November 1961 was followed by a reduction in numbers of individuals and species caught at Rydalmere. Temperature is less easy to relate to aphid numbers, and aphid species and even clones within species vary in their growth and reproduction at different temperatures (e.g. Turak *et al*. 1996, Asin and Pons 2001). Temperatures sufficient to cause wilting or death of host plants reduce aphid populations, and also to kill aphids directly by water loss and/or thermal damage to metabolic processes (Dampc *et al*., 2021). However, the highest temperatures and longest run of hot days in January 2021 did not reduce numbers or diversity in the following month. The process of acclimation may help to explain survival of aphids at higher temperatures (Hazell *et al.* 2010)

The aphid collections were commenced in April 2020, and the previous year's climate data probably played a major part in influencing aphid numbers and diversity. In 2019 rainfall was well below the mean for all years and all the monthly maximum temperatures exceeded the mean for all years. This conjunction of high temperatures and low rainfall resulted in an extreme bushfire season from September 2019 to May 2020. Level 2 water restrictions were enforced in Sydney: watering gardens was permitted only with watering cans. While the bushfires themselves may not have affected aphid populations (being mainly on exotic plants in suburban environments), the water restrictions combined with high temperatures are likely to have affected plant availability and plant health, with a knock-on effect on aphid populations. Any aphids flying near or in fire zones would have perished. No indigenous aphids were collected in either 1960-1 or 2020-1 and many would have been more at risk from bushfires than the exotic species, which use host plants mainly found in settled and agricultural areas.

Hughes *et al*. (1965) discussed wind speed as an important factor in the flight performance of aphids, and thence the likelihood that they would be trapped. They also considered the diversity of host plants in the source and landing zones. In their studies, the diversity of the catch increased from north to south for the Rydalmere, Burnley (Victoria) and New Town (Tasmania) sites, and was thought to reflect the species richness of plants, especially those from northern Europe. The numbers at Queensland sites were lower. Tropical regions are known to have fewer aphid species as discussed by Dixon *et al*. (1987).

Anthropogenic factors may also limit aphid diversity and numbers in suburban areas. These could include:

1. increased pesticide use, especially on flowers and vegetables
2. changes in garden plant diversity, for example the tendency to devote outside space to lawns, hedges and concreted or pebbled areas, or even artificial grass
3. denser housing and reduced green space
4. reduced untended areas within suburbs.

In summary, collections in 2020-1 contained fewer species than in 1960-61, and in each season in 2020-1, over 65% of species present in the earlier collections were not trapped. New immigrants made up 30-50% of each seasonal collection. Biological characteristics such as host range and annual cycle did not account for the missing species. Heavy rainfall is assumed to have reduced aphid populations and catch in November 1961 and in March-April 2021. Drought conditions, bushfires and water restrictions through 2019 are likely to have reduced aphid populations and diversity during 2020. Other human activities, related to the built environment and remaining green space, reduce habitat resources for aphids. Further data may help to define major factors in aphid species diversity.

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