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AIRBORNE ARTHROPODS COLLECTED IN SOUTH AUSTRALIA WITH A DROGUE-NET TOWED BY A LIGHT AIRCRAFT

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Abstract: A simple drogue-net was constructed for sampling air-borne organisms. The number of arthropods collected tended to be positively correlated with decreasing altitude of sampling and increasing temperature at the time of sampling. This reflects the dependence of the density of the aerial plankton and the dispersal of small organisms on the convectional movements of the air.

In the past a variety of techniques have been used to sample insects in the air (Hardy & Milne 1938; Freeman 1945; Johnson 1950; Glick 1960; Gressitt *et al* 1961; Harrell & Holzapfel 1966), but nothing of this nature appears to have been done before in Australia. The work reported here was undertaken in an attempt to capture a particular species of psyllid, *Cardiaspina densitexta* Taylor (White 1966), rather than to extend aerial sampling to Australia. However, the technique used, and the results obtained, are considered to be of sufficient value to warrant their publication.

Materials and Methods

The simplest and cheapest way to sample a particular volume of air for insects distributed in it, seemed to be to pass a collecting net through as much of this air as possible as quickly as possible. With this in mind, and spurred by a small budget, a simple drogue-net was designed and constructed (fig. 1). The net was made from a 15 inch (38 cm) diameter ring of 3/8″ (.9 cm) × 16 S. W. G. T. 35 steel tube to which was welded 12, 3/4″ (1.9 cm) × 16 S. W. G. square lugs for attaching the net, and 3, 16 S. W. G. wrap-around clips for attaching the ring to the bridle. The bridle was made of 3, 5-cwt. aircraft cables approximately 14″ (35.5 cm) long attached to the ring by 5-cwt. shackles, and terminating in a single 10-15-cwt. shackle, which in turn was connected to a 10-cwt. cable approximately 4′ 6″ (137 cm) long secured to the aircraft by a 16 S. W. G. clamp 1½″ (3.8 cm) in width and located around the starboard strut approximately 18″ (45.7 cm) down from the top attached fitting.

The nets of fine nylon or terylene were 3′ (91.3 cm) long, with a 15″ (38 cm) diameter mouth, and tapered to a point. The mouth was strengthened with a 1″ (2.54 cm) strip of canvas binding and fitted with 12, 7/16″ (1.1 cm) aperture metal eyelets. Twelve snap-clips attached to the square lugs enabled the nets to be attached or removed in a few seconds.

A nylon rope approximately 7′ (2.1 m) long was attached to the ring by a snap-clip

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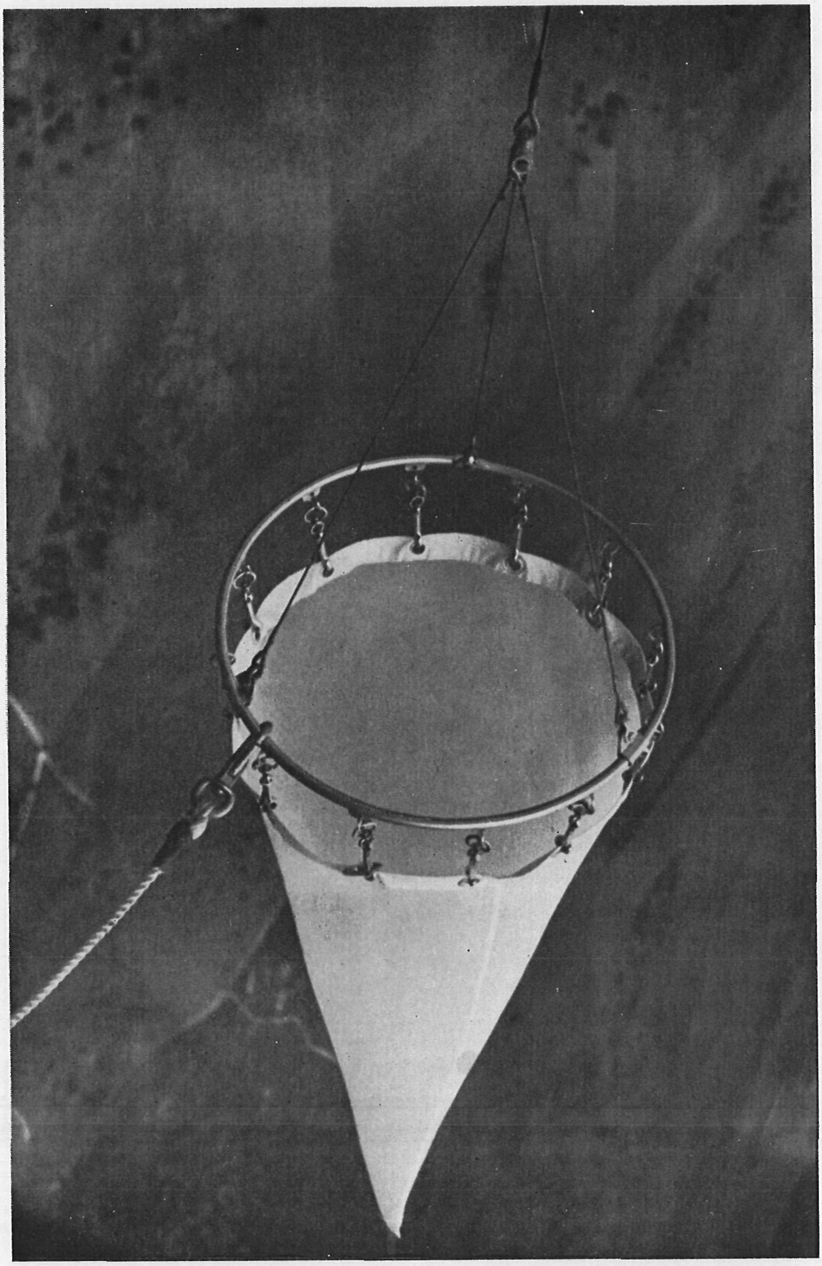

Fig. 1. The drogue-net in operation.

at one end and to the starboard seat supports by another snap-clip at the other end.

The total cost, including a dozen nets, was approximately A$30.00. The completed drogue was tested and passed by the Australian Department of Civil Aviation.

All collections were made over a relatively small area of the southeast of South Australia (fig. 2) using a Cessna 172 operating from a farm airstrip. Sampling runs were made, using 10° of flap and maintaining 60 to 65 knots, at fixed, predetermined heights.

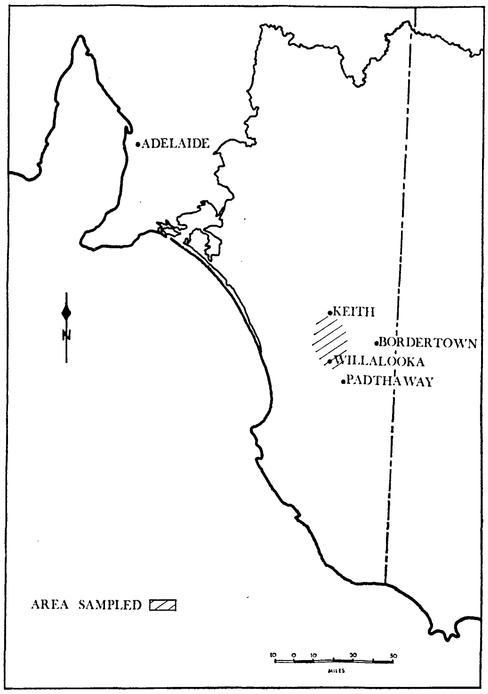

Fig. 2. Map of SE part of South Australia showing the area over which the aerial sampling was done.

When the airplane had reached the required height and was leveling out for a run, a net was removed from the plastic bag into which it had been sealed before leaving the laboratory, and clipped onto the ring. As soon as minimum cruising speed was reached the starboard door was held open against the airstream by the operator pressing against it with his head and the drogue dropped out through the gap.* At the completion of the timed run the door was again held ajar with the operator's head, and the drogue pulled into the cabin with the nylon rope. A knot was immediately tied in the net as close to the steel ring as possible, the snap-clips undone, and the net sealed into its plastic bag along with a record of date, time, altitude and duration of the sample. All bags were returned to the laboratory before being opened, and the nets immersed in 70 % alcohol before the knots were untied.

Results

The first trial proved the net to be easy to operate, stable in flight, and capable of withstanding air speeds well above the minimum cruising speed. The insects collected were, however, compressed into a ball of unidentifiable fragments. The insertion into each net of a loosely crumpled 7×5″ (17.8 cm×12.7 cm) sheet of 11 lb (5kg) bank paper overcame this difficulty; presumably by causing an "air cushion" immediately in front of it, and by providing crevices into which specimens could fall or crawl. In fact a number of insects and some spiders were found alive and uninjured in nets containing the crumpled paper.

* Removal of the starboard door would have made launching and retrieval of the drogue simpler but the resulting wind inside the cabin would have seriously interfered with most other activities such as note-taking and manipulation of the nets.

This preliminary experimentation occupied 50 minutes flying time and 37 minutes of net operation on the first day. On the following day 3 samples totaling 88 minutes were made in 110 minutes flying time.

After the results of these preliminary trials had been checked, and as soon as the weather was again suitable, the bulk of the sampling was done over 3 consecutive days; 17 samples totaling 272 minutes being completed in 400 minutes flying time. Three more samples totaling 68 minutes in 110 minutes flying time were made over 2 days, some 14 days later. Thus, including the preliminary trials, 69 % of the flying time was spent sampling, and over the 4 days when the bulk of the collecting was done, 71 % of the time in the air was used for sampling. It would not be difficult to get an "efficiency" of over 80 % of the flying time being used for sampling in any future work with this equipment. The total cost of all flying was A$145.00.

Table 1 shows details of each sample and the number caught in each, while Table 2 lists the insects and other organisms caught at each altitude.

Table 1. Details of Aerial Samples.

Date & Sample Number	Max. Temp. for Keith in °F (°C)	Height in meters	Time (Mid Point)	Durations (Minutes)	Catch Total	Catch Per Minute
5. XI. 1964						
1	64° (17.8°C)	150	11.10 a. m.	20	10	0.500
2		//	12.01 p. m.	18	–	–
3		//	2.10 p. m.	50	–	–
10. XI. 1964						
1	71° (19.7°C)	150	10.02 a. m.	15	2	0.134
2		//	12.20 p. m.	15	16	1.067
3		//	12.40 p. m.	15	18	1.200
4		//	1.00 p. m.	15	12	0.800
11. XI. 1964						
1	74° (23.3°C)	150	11.16 a. m.	15	18	1.200
2		300	11.35 a. m.	15	24	1.600
3		600	11.53 a. m.	17	5	0.294
4		150	12.13 p. m.	15	18	1.200
5		300	2.24 p. m.	15	32	2.134
12. XI. 1964						
1	86° (30°C)	150	10.01 a. m.	15	85	5.666
2		//	10.30 a. m.	30	235	7.830
3		300	11.01 a. m.	15	12	0.800
4		150	12.33 p. m.	15	74	4.934
5		105	12.53 p. m.	15	129	8.600
6		//	1.12 p. m.	15	91	6.060
7		150	5.11 p. m.	15	22	1.467
8		//	5.29 p. m.	15	5	0.334
25. XI. 1964						
1	84° (28.9°C)	150	12.22 p. m.	36	14	0.389
27. XI. 1964						
1	70° (38.9°C)	150	10.22 a. m.	15	2	0.134
2		//	10.40 a. m.	17	1	0.059
23	–	–	–	428	825	1.927

Table 2. List of spiders, mites & insects captured.

Order, family, genus, and species	Number collected at indicated altitude in meters				Total
	600	300	150	105	
ARANEIDA:					
Linyphiidae: Indet. spp. (immature)			4	1	5
(Erigoninae): Indet. sp. (〃)			1		1
Theridiidae: Indet. sp. (〃)			1		1
(Asageninae): *Teutana* sp. (〃)		1			1
	-	1	6	1	8
ACARINA:					
Macrochelidae: *Macrocheles* sp.			2		2
Ascidae: *Cheiroseius mackerrasae* (Womersley)			3		3
	-	-	5	-	5
PSOCOPTERA:					
Indet. sp.				1	1
	-	-	-	1	1
THYSANOPTERA:					
Aeolothripidae: *Desmothrips australis* (Bagnall)				1	1
Phlaeothripidae: *Idolothrips spectrum* Haliday				1	1
Indet. sp.				1	1
Thripidae:					
Anaphothrips sp.			2		2
Isoneurothrips australis Bagnall			9	5	14
Limothrips oerealium Haliday			3		3
Odontothripiella? australis Bagnall			2		2
Thrips sp.		1	12	7	20
	-	1	28	15	44
HETEROPTERA:					
Lygaeidae:					
(Lygaeinae): *Nysius vimitor* Bergroth			1		1
	-	-	1	-	1
HOMOPTERA:					
Cicadellidae:					
(Typhlocybinae): *Erythroneura ni* Myers			4		4
Austroasca (*Empoasca*) sp.			3		3
(Deltocephalinae): *Deltocephalus* sp.				1	1
Aleurodidae: Indet. sp.				1	1
Psyllidae: *Cardiaspina densitexta* Taylor (5th Instar exuviae)		1	1		2
Ctenarytaina sp.			1		1
Eucolyptolyma sp.			1		1
Psylla sp.			1		1
Aphididae: *Aphis craccivora* Koch				2	2
Myzus persicae (Sulz.)				1	1
Rhopalosiphum padi (L.)				1	1
Rhopalosiphum? rufiabdominalis (Sasaki)			1		1
	-	1	12	6	19

Table 2 continued.

Order, family, genus and species	Number collected at indicated altitude in meters				Total
	600	300	150	105	
LEPIDOPTERA:					
Nepticulidae: Indet. sp.				1	1
	-	-	-	1	1
COLEOPTERA:					
Cryptophagidae: *Cryptophagus* sp.			1		1
Curculionidae:					
(Erirrhininae): *Cyttalia oleariae* Lea			1		1
Indet. sp.			1		1
(Rhamphinae): *Rhamphus* sp.				1	1
Chrysomelidae: *Cryptocephalus* sp. A			1		1
Cryptocephalus sp. B			2		2
Hydrophilidae: *Enochrus* sp.			1		1
Lathridiidae: *Melanophthalma australis* Blackburn			1		1
Staphylinidae:					
(Oxytelinae): *Trogophloeus* sp. A			4		4
Trogophloeus sp. B			3		3
	-	-	15	1	16
HYMENOPTERA:					
Pteromalidae: *Coelocyba* sp.		1			1
Indet. sp. A		1			1
Indet. sp. B			1		1
Indet. sp. C			2		2
Indet. sp. D			1		1
Indet. sp. E			1		1
Indet. sp. F			1		1
Indet. sp. G				1	1
Indet. sp. H				2	2
Indet. sp. I				1	1
Indet. sp. J			1		1
Formicidae: Indet. sp. A			1		1
Indet. sp. B			1		1
Indet. sp. C			1		1
Indet. sp. D				3	3
Indet. sp. E				1	1
Indet. sp. F				2	2
Indet. sp. G			1		1
Braconidae: Indet. sp. A	1			2	3
Indet. sp. B				1	1
Bethylidae: Indet. sp.		1			1
Scelionidae: Indet. sp.			2		2
Encyrtidae: *Elasmus* sp.			1		1
Platygasteridae: Indet. sp.				1	1
	1	3	14	14	32
DIPTERA:					
Tipulidae: Indet. sp. A			1		1
Indet. sp. B			1		1
Ceratopogonidae: *Dasyhelea* sp.		1	7	3	11
Forcipomyia sp.				1	1
Atrichopogon sp.			1		1
Chironomidae: *Chironomus tepperi* Skuse		12	12	31	55
Chironomus indet. spp.		1	20	2	23

Table 2 continued.

Order, family, genus and species	Number collected at indicated altitude in meters				Total
	600	300	150	105	
Procladius paludicola Skuse		1	3	2	6
Syncricotopus pluriserialis (Freem.)				1	1
Indet. spp.	1	1	16	1	19
Simuliidae: *Simulium ornatipes* Skuse			1		1
Psychodidae: Indet sp.			2		2
Cecidomyiidae: Indet. spp.		20	20	7	47
Mycetophilidae: *Mycetophila* sp.			1		1
Sciaridae: Indet. spp.		1	5		6
Stratiomyidae: *Odontomyia decipiens* (Guer.)			1		1
Empididae: *Atrichopleura* sp.			1		1
Drapetis (s. l.) sp.			1		1
Dolichopodidae: *Hydrophorus* sp.			1		1
Chrysotus sp.			1		1
Syrphidae: *Ischiodon grandicornis* Macq.		1	2		3
Syrphus viridiceps Macq.			1		1
Phoridae: Indet. spp.			4		4
Lauxaniidae: *Poecilohetaerus schineri* Hend.		3	10	1	14
Sphaeroceridae: *Leptocera* sp.		1	16		17
Leptocera (at least 2 spp.)			10		10
Agromyzidae: *Cerodontha australis* Mall.	1		7	4	12
Fergusoninidae: *Furgusonina* sp. near *curriei* Tonn.		1			1
Ephydridae: *Scatella nitidithorax* Mall.	1	14	130	57	202
Scatella alticeps Mall.		1	19	5	25
Scatella sp. A	1	1	102	46	150
Scatella sp. B			1		1
Eleides chloris Cress.			2		2
Atissa suturalis Cress.			7	5	12
Nostima sp. near *duosetosa* Cress.			3	1	4
Hydrellia sp. near *victoria* Cress.			2		2
Indet. sp. C			13	4	17
Indet. sp. D				2	2
Indet. sp. E			1		1
Indet. spp.			2		2
Drosophilidae: *Scaptomyza* sp. near *australis* Mall.		1	16	6	23
Chloropidae: *Conioscinella* sp.		1	1		2
Lioscinella sp.		1		1	2
Indet. spp.			3	1	4
Muscidae: *Ophyra analis* Macq.			1		1
Limnophora sp.			1		1
Calliphoridae: *Aphyssura minuta* Mall.			1	1	2
	4	62	450	182	698
TOTAL:	5	68	531	221	825

Discussion

On the assumption that the air through which the net passed was chosen at random, that the speed of the net was constant, and that deflection from the mouth of the net and turbulence from the aircraft's wing were the same for all samples, it seemed reasonable to compare samples on the basis of numbers caught per unit time. This showed that the numbers caught tended to increase with both decreasing altitudes of sampling (Table 3) and with increasing daily maximum temperature at Keith, the nearest weather station to the site of sampling (Table 4). There was also a tendency for more insects to be caught towards the middle of each day (Table 1). These results reflect the dependence of the density of the aerial plankton on the development of "thermals" carrying small organisms up into the atmosphere where turbulence mixes and scatters them before they fall back to earth as the air cools in the afternoon. This in turn illustrates the way in which small day-flying insects are widely dispersed (Lewis & Taylor 1965) and the large numbers of insects that must be dispersed in this way (Collier & Baker 1934).

Table 3. The number caught in relation to air temperature.

Max. Temp. for Keith in F° (°C)	Number caught per minute			
	All Samples	Time Sampling (Minutes)	11 a.m.-2 p.m. at 150m or less	Time Sampling (Minutes)
60-70 (15.6-21.1)	0.108	120	0.264	38
71-80 (21.7-26.7)	1.059	137	1.093	75
81-90 (27.2-32.2)	3.900	171	3.800	81

Table 4. The number caught in relation to altitude.

Height of Sample in meters	Number caught per minute			
	All Samples	Time Sampled (Minutes)	Three main sampling days (10, 11, and 12. XI. 1964	Time Sampled (Minuets)
105	7.370	30	7.370	30
150	1.580	336	2.805	180
300	1.511	45	1.511	45
600	0.294	17	0.294	17

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LITERATURE CITED

Colins, C. W. & W. L. Baker. 1934. Exploring the upper air for wind-borne gypsy moth larvae. *J. Econ. Ent.* **27**: 320-27.

Freeman, J. A. 1945. Studies in the distribution of insects by aerial currents. The insect population of the air from ground level to 300 ft. *J. Anim. Ecol.* **14**: 128-54.

Glick, P. A. 1960. Collecting insects by airplane, with special reference to dispersal of the potato leafhopper. *U. S. D. A. Tech. Bull.* **1222**: 1-16.

Gressitt, J. L., J. Sedlacek, K. A. J. Wise & C. M. Yoshimoto. 1961. A high speed airplane trap for airborne organisms. *Pacif. Ins.* **3**: 549-55.

Hardy, A. C. & P. S. Milne. 1938. Studies in the distribution of insects by aerial currents. Experiments in aerial tow-netting from kites. *J. Anim. Ecol.* **7**: 199-229.

Harrell, J. C. & E. Holzapfel. 1966. Trapping air-borne insects on ships in the Pacific, Part 6. *Pacif. Ins.* **8**: 33-42.

Johnson, C. G. 1950. The comparison of suction trap, sticky trap and tow net for the quantitative sampling of small airborne insects. *Ann. Appl. Biol.* **37**: 268-85.

Lewis, T. & L. R. Taylor. 1965. Diurnal periodicity of flight by insects. *Trans. R. Ent. Soc. Lond.* **116**: 393-479.

White, T. C. R. 1966. Food and outbreaks of phytophagous insects with special reference to *Cardiaspina densitexta* Taylor, (Psyllidae, Homoptera) on *Eucalyptus fasciculosa* F. v. M. (Myrtaceae) in South Australia. Ph. D. Thesis, University of Adelaide.