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Observations on the role of mollusks and planarians in the transmission of Angiostrongylus cantonensis infection to man in new caledonia*

by

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Abstract: Observations from October 1965 to May 1967, on the role played by mollusks and other invertebrates in the transmission of *Angiostrongylus cantonensis* infection to man on the South Pacific island of New Caledonia revealed that various snails, slugs and a planarian, ocurring in gardens supplying considerable amounts of edible green vegetation to local markets, were commonly infected with third-stage larvae of *A. cantonensis*. The veronicellid slugs, *Vaginulus plebeius* and *Laevicaulus alte*, were the most frequently and intensively infected mollusks and they probably serve as the chief reservoir of infection for feral rats. The high level of infection in these slugs not only results in maintaining a large population of infected rats but is of importance in the dispersal of infective larvae into planarians serving as paratenic hosts for the parasite. There is no apparent seasonal diference in the rate and level of infection among the slugs, although they have a dormant period during the cooler months (July to September) of the year. It is suggested that planarians are probably the single most important source of human infection in New Caledonia. The planarians show a marked seasonal occurrence, reaching their peak during the cool months of the year, which corresponds to the peak vegetable growing season. Their highly carnivorous habits in their attacking of both snails and slugs results in a high level of infection although individual planarians harbor relatively low numbers of larvae, usually less than 10. Their small size, their ability to fragment easily, and their rapid dehydration to form inconspicuous black masses contaminating lettuce and other vegetables make them an ideal vehicle for the transmission of *A. cantonensis* to man.

Since the discovery in the early 1960's that *Angiostrongylus cantonensis*, the rat lungworm, is the primary agent causing human eosinophilic meningitis or eosinophilic meningoencephalitis in many islands of the Pacific and in many countries of Southeast Asia there have been numerous investigations into the

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epidemiology of the disease. Most of these studies have clearly demonstrated that the manner in which the disease is acquired is related to the preferential food habits of the particular population involved (**Rosen** *et al.*, 1961; **Alicata,** 1963; **Rosen** *et al.*, 1967; **Punyagupta** *et al.*, 1970; **Yii** *et al.*, 1975). This correlation of disease ocurrence and food habits reflects the numerous opportunities for human infection presented by the wide range of molluscan intermediate hosts and the numerous invertebrate and vertebrate animals that can serve as paratenic hosts for the parasite. Infective-stage larvae have been found in many mollusks (**Wallace** and **Rosen,** 1969a, 1969b), as well as in land planarians (**Alicata,** 1962,1963), shrimp and crabs (**Rosen** *et al.*, 1967; **Alicata,** 1965; **Wallace** and **Rosen,** 1966), fish (**Wallace** and **Rosen,** 1967), amphibians and reptiles (**Ash,** 1968), and mammals (**Alicata,** 1964).

Despite the numerous opportunities for human infection presented by readily available intermediate and paratenic hosts other factors appear to be of importance in the occurrence of the disease. Studies in Thailand (**Punyagupta** *et al.*, 1970) and in Taiwan (**Yii** *et al.*, 1975) have demonstrated the influence of climate on the distribution of the disease in time. Prior to these latter two studies Rosen and his colleagues (**Rosen** *et al.*, 1967) had noted a marked seasonal occurrence of the disease on the South Pacific island of New Caledonia. Since initial observations by these workers and others (**Alicata,** 1963) had indicated a correlation between cases of the disease and the peak vegetable growing season on the island, a study was designed to investigate the epidemiologic factors involved in transmission of the disease.

A survey of the market gardens supplying significant quantities of produce to markets in the capital city, Noumea, was undertaken from late 1965 to mid-1967. This report presents data from these gardens on the molluscan and planarian populations, the factors influencing the size of these populations, the rate and intensity of infection by *A. cantonensis* in these invertebrates and how all these factors interrelate to allow for transmission of this infection to man.

MATERIAL AND METHODS

The market gardens selected for study were in the immediate vicinity of the capital city, Noumea, and were the major suppliers of produce to the local markets. These gardens were scattered on the outskirts of different sections of the city. All gardens were bordered on two or more sides by thick brush and vegetation. In close association with each garden were either small storage sheds or poultry-raising pens that provided excellent shelter for rats that were abundant in all gardens.

Although various vegetables were grown in the gardens, the dominant crops were the green salad vegetables, including several varieties of lettuce and cabbage. The growing season for these started in March or April and finished toward the end of the year. During the hot summer months of December to February the bulk of the lettuce consumed by the local population was imported from Australia.

The methods used for sampling the molluscan and planarian populations varied depending upon their abundance. Since slugs and planarians are mainly nocturnal in their habits most collections were made at night. Collections were made several times each week for the period spanning October, 1965 to April, 1967. When mollusks were especially abundant, usually during and following rainy periods, small and large slugs were collected from all parts of the gardens themselves as well as in the brush immediately bordering the gardens. In the hot summer

months (December-February) there was a marked reduction in slugs so that all collected were examined. Planarians were found only in the cooler months (June-September) and all collected were examined.

Two methods were used for examining mollusks and planarians. Small snails and slugs were examined by press preparations of the entire animal between thick glass plates under a dissecting microscope. Large snails and slugs were subjected to pepsin digestion by techniques previously described **(Wallace** and **Rosen,** 1969c). The veronicellid slugs were weighed and measured individually prior to their examination; however, very young veronicellids (less than 2 cm in length) were often pooled in groups of 3 to 5 for digestion. When nematode larvae were found they were examined with a compound microscope for morphologic features characteristic for *A. cantonensis* and other lungworm larvae **(Ash,** 1970). In some instances larvae were fed to white rats and the developing adult worms were searched for in the meninges of these animals 3 weeks later.

RESULTS

Species of animals present in gardens: The predominant species of rat occurring in association with all gardens was *Rattus norvegicus; R. rattus* was present in fewer numbers. No attempt was made to continuously survey rats for infection with *A. cantonensis.* During the first year approximately 70% of 45 *R. norvegicus* trapped around the gardens studied were infected but only one of 9 *R. rattus* was infected.

Although cats and dogs were owned by most gardeners there was little evidence of their frequent defecation in gardens. Lungworms were never found in dogs but cats were infected with two metastrongylid species, *Aelurostrongylus abstrusus* and *Anafilaroides rostratus.* Hookworms and ascarids were the only other intestinal nematodes commonly found in dogs and cats.

Three species each of slugs and snails and one species of planarian were found in the market gardens studied. The slugs included two veronicellid species, *Laevicaulus alte* (Férussac, 1823) Hoffmann, 1929 and *Vaginulus (Sarasinula) plebeius* (Fischer, 1868) Baker, 1931, and the small black slug, *Deroceras laeve* (Müller, 1774). The three snails found were *Helix (Cryptomphalus) aspersa* (Müller, 1774), *Bradybaena similaris* (Férussac, 1821) and *Subulina octona* (Bruguiere, 1792). The only land planarian species occurring in the gardens was *Geoplana forsterorum* Schroder, 1924.

Habits of molluks and planarians: The large veronicellid slugs, *L. alte* and *V. plebeius,* live for the most part in the brush bordering the gardens. They remain under cover during the day and at dark migrate into the gardens where they feed primarily on vegetation lying on the ground in and between the planted rows of lettuce and other produce. Once these slugs attain a length of more than 2-3 cm they feed almost exclusively on vegetation on the ground whereas the young, small slugs may also climb the plants to feed on the leaves. These slugs are seasonal; during the cool months of the year (July to September) the adult slugs burrow underground or under vegetation and do not feed on the surface of the ground. Eggs hatch toward the end of the year and tiny veronicellids are the dominant population during December and January; they grow rapidly, attaining lengths of 3-7 cm within a few months and may travel considerable distances to feed before returning to the periphery of the gardens. Heavy rainfall, resulting in extremely

muddy conditions, discouraged their activity although with normal rainfall they thrived. In the absence of rainfall for extended periods of time, during the warm months of the year, the slugs would remain active unless windy conditions prevailed; wind apparently caused rapid drying of the slugs and was detrimental to their activity and survival.

The small black slugs, *D. laeve* have different habits from the veronicellids. They tend to remain in the gardens where they are usually found at the base of lettuce plants or within the folds of the inner leaves. These slugs were found feeding at all times of the day but they reached peak numbers at night. They do not travel long distances and rarely migrate to the periphery of the gardens. Their feeding behavior greatly influences their opportunities for exposure to lungworm larvae that have become dispersed on the ground from disintegrating rat feces. As the veronicellid slugs increased in size and consequently spent more time on the ground this allowed for maximum exposure to larvae whereas the restricted movements and feeding by the young veronicellids and *Deroceras* allowed for lesser exposure to contaminated soil.

The most prevalent snail in all gardens was *Helix aspersa.* This snail multiplied rapidly, reached astonishing numbers at times and was the most destructive mollusk to growing plants. They were found everywhere in and around gardens and their large size seemed to be no obstacle to their climbing plants. Of the three types of snails in the gardens this species had the maximum opportunity for exposure to soil contaminated with lungworm larvae. *Bradybaena similaris* was the next most frequent snail and was usually found on or near plants. *Subulina octona* was found infrequently on plants, generally occurring on the periphery of the gardens, and was never present in large numbers.

Planarians were markedly seasonal in their occurrence. They were abundant in gardens during the cooler and generally wetter period of the year, from June to September or October. As soon as the air temperature rose to much above 16 C they were rarely found in the gardens, presumably because the dry conditions resulted in rapid dehydration of the planarians. When present they could be found everywhere in and around the gardens, both on the ground and on vegetation. They are extremely carnivorous and were commonly found feeding on the tissues of dead and dying snails and slugs.

Infections in mollusks and planarians: From October 1965 through April 1967 more than 1500 veronicellid slugs were examined for lungworm infections. In Table 1 the rates of infection in *V. plebeius* and *L. alte* on a monthly basis, for all gardens, are given. It was found that although *V. plebeius* was twice as common as *L. alte* the rate of infection in the latter species was approximately double that of the former. It can also be seen that in 1966 the veronicellids were not found during the months of August and September. In New Caledonia the cool season extends from June or July into September. Following the cool season the temperatures increase and usually there is an increase in rainfall. The year 1965 was characterized by a prolonged drought so that following the end of the cool season there was a dry period that extended into December. Veronicellids where not found in gardens until December 1965 and January of 1966; however, they began to reappear in the gardens in October of 1966, several months earlier than the previous year, because rainfall was heavy following the advent of warm weather.

TABLE 1

Prevalence of infection by third-stage larvae of Angiostrongylus cantonensis *in* Vaginulus plebeius *and* Laevicaulus alte *collected in market gardens in Noumea from October 1965 through April 1967*

	V. plebeius		*L. alte*	
Date	No. Pos./No. Exam.	%Pos.	No. Pos./No. Exam.	% Pos.
1965:				
October	0/3	0	1/2	50
November	1/2	50	2/2	100
December	0/0*	--	0/0	--
1966:				
January	2/53	4	1/3	33
February	23/133	17	26/98	27
March	6/54	11	11/39	28
April	5/31	16	22/41	54
May	16/117	14	18/55	32
June	24/156	15	7/37	19
July	5/49	10	8/29	28
August	0/5	0	0/0*	--
September	0/0*	--	0/0*	--
October	1/6	16	20/66	31
November	3/30	10	18/48	37
December	7/35	20	7/19	37
1967:				
January**	--	--	--	--
February	25/105	24	4/51	8
March	15/130	12	5/35	14
April	10/110	9	7/20	35
Totals:	143/1019	14	157/545	29

* None found at this time.

** Planarians searched for but not found.

Despite the erratic numbers of slugs caught and examined the rates of infection among the two species remained constant at all times of the year. In general, it can probably be assumed that the older a slug becomes, thus increasing in length and weight, there is a greater probability for it to become infected; this is evident from Tables 2 and 3. In addition to a greater frequency of infection among longer and heavier slugs there was a corresponding increase in the larval yields from each slug, although this was more evident than in *V. plebeius* in *L. alte.* As can be seen in Tables 2 and 3 the rates of infection in small slugs (less thatn 2 cm long) of either species were extremely low when they were examined individually; consequently, small veronicellids were frequently pooled in groups of 3 to 5 slugs to expedite their examination. Data from these pool groups are not included in Tables 1-3. A total of 17 pool groups of *V. plebeius* of 59 pool groups examined were positive for larvae. Five pool groups of *L. alte* of 17 groups examined contained larvae. The numbers of larvae found in these pools were low, usually well under 100 larvae, and more than likely represented only one or two infected slugs within each positive group.

Although *A. cantonensis* larvae were the usual larvae found in veronicellid slugs, other nematode larvae were occasionally found. Hookworm larvae (either *Ancylostoma caninum* or *A. tubaeforme)* occurred in small numbers in 18 *V. plebeius* and in 19 *L. alte.* Four *V. plebeius* were infected only with *Aelurostrongylus abstrusus* larvae; mixed infections with cat and rat lungworm larvae may have occurred occasionally but when *A. cantonensis* larvae were identified other larvae were not examined critically.

A total of 721 *Deroceras* were examined and 35 (5%) were infected with *A. cantonensis.* The numbers of larvae recovered ranged from 1 to 466 with a mean of 47 and a median of 9 larvae per slug.

TABLE 2

Larval counts of Angiostrongylus cantonensis *in relation to the lengths of* Vaginulus plebeius *and* Laevicaulus alte

Slug species Length (mm)	No. Pos. / No. Exam.	% Pos	Larval Counts Mean	Median	Range
V. plebeius:					
10 – 19	0/116	0	--	--	--
20 – 29	6/230	3	104	37	1 – 770
30 – 39	30/193	15	371	43	1 – 5860
40 – 49	50/268	19	903	136	1 – 14600
50 – 59	47/177	26	880	112	1 – 9500
> 60	10/35	28	558	177	1 – 1850
L. alte:					
10 – 19	1/22	5	3	--	--
20 – 29	3/53	6	134	57	23 – 322
30 – 39	40/180	21	458	142	1 – 2730
40 – 49	73/183	40	442	80	1 – 8600
50 – 59	26/76	34	370	38	1 – 3430
> 60	14/31	45	110	23	1 – 559

Although many snails were examined in the course of the study early observations suggested they were of little epidemiologic importance in the maintenance of *A. cantonensis* in nature. *Helix aspersa,* the largest and most numerous species was found to be highly resistant to infection. Several hundred *Helix,* of all sizes, were examined both individually and in pools of 5 of more. These snails were taken from within the gardens as well as from the bordering areas where rat activity was at its maximum. No natural infections with *A. cantonensis* were found. To determine the susceptibility of *Helix* to *A. cantonensis* infection 50 snails of varying sizes were exposed to large numbers of first-stage larvae; in only a

few snails were infective-stage larvae recovered, suggesting that *H. aspersa* is not a good host for the parasite. Of the other snails examined 8 of 251 *Bradybaena* were infected; larval counts ranged from 3 to 14. None of 174 *S. octona* were found infected.

Table 4 summarizes infections found in the land planarian, *Geoplana forsterorum*, in the 4 major gardens surveyed. In one garden (F-11), observed from October, 1965, few planarians were encountered until April of 1966. Collections in the three other gardens (F-17, F-18, F-20) were started in June of 1966, at the beginning of the cool season. The numbers of planarians collected decreased during the warmer months and in several instances they were not found at all. Although some planarians had impresive numbers of larvae considering their small, ribbon-like size, it can be seen that the majority had less than 10 larvae each; 121 out of the 184 (66%) infected planarians had 10 larvae or less in their tissues (Table 5).

TABLE 3

Larval counts of Angiostrongylus cantonensis *in relation to the weights of* Vaginulus plebeius *and* Laevicaulus alte

Slug species Weight (gms)	No. Pos. No. Exam.	%Pos.	Larval Counts Mean	Larval Counts Median	Range
V. plebeius:					
0.1 – 0.9	4/296	1	221	52	8 – 778
1.0 – 1.9	20/173	11	222	49	1 – 1620
2.0 – 2.9	22/124	18	435	30	1 – 5860
3.0 – 3.9	24/138	17	488	29	1 – 2450
4.0 – 4.9	26/129	20	1427	210	1 – 14600
5.0 – 5.9	28/85	33	1009	241	1 – 9500
6.0 – 6.9	10/40	25	549	130	4 – 3370
> 7.0	9/34	26	723	550	3 – 1850
L. alte:					
0.1 – 0.9	2/57	3	170	– –	17 – 322
1.0 – 1.9	23/129	18	324	57	1 – 1140
2.0 – 2.9	40/110	36	539	247	1 – 3030
3.0 – 3.9	42/111	38	538	117	1 – 8600
4.0 – 4.9	22/59	37	75	15	1 – 620
5.0 – 5.9	13/36	36	269	140	2 – 1090
6.0 – 6.9	7/26	27	172	22	1 – 842
> 7.0	8/17	47	485	27	1 – 3430

DISCUSSION

Despite the fact that mollusks are an essential and indispensable part of the life cycle of *A. cantonensis* there have been few quantitative reports on infections in these hosts in nature (**Wallace** and **Rosen,** 1969b; **Lim** and **Heyneman,** 1965). As

TABLE 4

Summary of infections by Angiostrongylus cantonensis *third-stage larvae in planarians* (Geoplana forsterorum) *collected from four market gardens in Noumea, New Caledonia*

Date	F-11 No. Pos. No. Exam.	F-17 No. Pos. No. Exam.	F-18 No. Pos. No. Exam.	F-20 No. Pos. No. Exam.
1965:				
October	0/1	*	*	*
November	0/2			
December	0**			
1966:				
January	1/1			
February	1/3			
March	0**			
April	4/6			
May	2/2			
June	12/21	2/8	5/13	8/13
July	13/25	8/19	5/8	4/12
August	20/50	4/16	3/3	8/25
September	6/30	1/14	0/2	0**
October	5/18	1/12	0**	0**
November	0/2	0**	0**	0**
December	0**	0**	0**	0**
1967:				
Jan.-March	0**	0**	0**	0**
April	4/10	2/10	4/7	12/23
May	***	20/48	20/27	9/36
Totals:	68/171	38/127	37/60	41/109

* Observations not started in these gardens until June, 1966

** Planarians searched for but not found

*** Not looked for.

pointed out by **Wallace** and **Rosen** (1969b) there are many factors governing the importance of a given molluscan species as both an intermediate host for *A. cantonensis* as well as the degree of the role it plays in the maintenance of the life cycle in nature. In terms of a mollusk's ability to serve as an intermediate host the most important factors appear to be its innate susceptibility to infection and whether its biological behavior is such that it comes into frequent contact with first-stage larvae excreted in the feces of infected rats.

In the present study it was determined that veronicellid slugs were the most frequent and heavily infected mollusks in New Caledonian gardens. The smaller slug, *D. laeve*, and the 3 snail species, *H. aspersa*, *B. similaris* and *S. octona*, were infrequently infected although they can be readily infected with *A. cantonensis* under laboratory conditions (**Wallace** and **Rosen**, 1969a; **Malek**, 1962). Thus, it appears that the biological behavior of these molluscan species is the dominant factor in their acquisition of infection. Similar findings for *Deroceras* as well as for

Bradybaena, Subulina and other snail species have been previously reported (**Wallace** and **Rosen,** 1969b; **Lim** and **Heyneman,** 1965). However, it has been pointed out that the most heavily infected mollusks may not be the most important species for maintenance of *A. cantonensis* in feral rats since rats are usually killed when a primary infection is brought about by large numbers of larvae (**Wallace** and **Rosen,** 1969b). Undoubtedly, some rats are killed in nature by their infections but **Heynemann** and **Lim** (1965) demonstrated that initial infections with a few larvae conferred protection on rats in subsequent exposures when normally lethal numbers of larvae were ingested.

Since the ingestion of raw mollusks is not the usual method of human infection in the Pacific Islands the concentrations of large numbers of infective larvae in certain molluscan species ensures a greater dispersal of larvae into paratenic hosts that feed on these mollusks. In analyzing 243 human cases of eosinophilic meningitis occurring in New Caledonia and adjacent islands it was demonstrated (**Rosen** *et al.*, 1967) that the mode of transmission of the disease was most closely associated with the eating of some form of raw green vegetation. This situation differed from that seen in other islands of the Pacific or in Taiwan and Thailand where the usual causes of human infection could be traced to the consumption of uncooked mollusks, shrimp and crabs or sauces prepared from them (**Rosen** *et al.*, 1967; **Punyagupta** *et al.*, 1970; **Yii** *et al.*, 1975). Prior to the present study Alicata (**Alicata,** 1963) had suggested that since most cases of eosinophilic meningitis on New Caledonia occurred during the cooler months of the year that these infections resulted from the accidental ingestion of mollusks or planarians on poorly washed lettuce, other green vegetation or fruit. As a consequence of these reports the present study was carried out to attempt to determine the method of human infection by observing the activities and infection rates in mollusks and planarians.

Continued observations for periods ranging from 12 to 20 months suggested a pattern of infection in the molluscan hosts and planarians that provides a possible explanation for human infections. Firstly, in New Caledonia enormous quantities of lettuce and other vegetables are used for salads and most patients with the disease had a history of eating raw green vegetation, whereas raw animal foods were infrequently eaten (**Rosen** *et al.*, 1967). The suggestion by various workers that the accidental ingestion of mollusks on lettuce or similar raw vegetation as probably the primary method of human infection is probably untenable in light of the present data. Mollusks of a size to be easily overlooked if vegetation is not well cleaned, were rarely found infected. Tiny veronicellids were not found infected and

TABLE 5

Summary of larval counts of Angiostrongylus cantonensis *in planarians* (Geoplana forsterorum) *from market gardens in Noumea*

Garden No.	Planarians infected	Larval counts/Planarian		
		Mean	Median	Range
F - 11	68	18.5	5	1 – 194
F – 17	38	19	6	1 – 132
F – 18	37	18	9	1 – 74
F – 20	41	7.6	3	1 – 40

Deroceras were rarely infected; small snails were also infrequently infected. Furthermore, tiny veronicellids simply were not found in the cooler months of the year; they generally appeared after the onset of warm weather, usually from mid-December to January.

Planarians seem to be the most logical paratenic hosts responsible for human infection. Infection rates in these planarians were high, which was due to their habits of feeding on dead snails and slugs. The seasonal appearance of planarians, during the cool months of the year, immediately preceded the time at which most human cases occurred. Planarians are extremely prone to desiccation and they were found commonly on lettuce plants as tiny, desiccated masses. Despite their extreme desiccation, when placed in water and rehydrated it was found that *A. cantonensis* infective larvae were still viable and infective to rats. Unquestionably, improper cleaning of lettuce, strawberries, or other vegetation that is eaten raw could result in accidental ingestion of planarians. Furthermore, the numbers of larvae present in the planarians is compatible with the suggestion that low numbers of larvae can produce eosinophilic meningitis (**Rosen** *et al.*, 1967; **Alicata** and **Jindrak,** 1970).

Another unlikely method of human infection in New Caledonia is by the ingestion of raw vegetation on which mollusks have shed mucus containing infective larvae, a suggestion that was offered for the lack of human cases in Malaysia (**Heyneman** and **Lim,** 1967). These workers found that naturally infected slugs, *Microparmarion malayanus,* spontaneouusly shed *A. cantonensis* larvae in the mucous trail left while feeding on lettuce. However, in several experiments conducted with the veronicellids in New Caledonia (**Ash,** unpublished observations) it was found that veronicellids rarely shed larvae in their mucous trails and in the few instances in which it occurred the larvae failed to survive for more than a few hours. In other experiments it was found that only a few larvae escaped from intact *L. alte* drowned in water (**Cheng** and **Alicata,** 1964). Apparently, the epidermis of *Microparmarion* is rather thin whereas in the veronicellids it is thick and leathery and does not allow for ready egress of larvae from the internal tissues.

It appears that in New Caledonia the occurrence of most cases of eosinophilic meningitis, during and just following the cool season of the year, is directly associated with the influx of infected planarians in gardens supplying produce to local markets and their subsequent accidental ingestion on lettuce or other raw vegetable products. This seems to be the most reasonable explanation for the distribution in time of human cases since epidemiologic studies (**Rosen** *et al.*, 1967) demonstrated that raw mollusks, shrimp and crabs were not eaten by most infected individuals. Interestingly, an extensive health education campaign on the island in late 1966 and 1967, urging the proper and thorough washing of lettuce and other vegetables, prior to their consumption, resulted in a marked decrease in cases of eosinophilic meningitis over the next few years (G. Loison, personal communication).

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RESUMEN

Las observaciones llevadas a cabo de octubre de 1965 a mayo de 1967 en la isla Nueva Caledonia, en el Pacífico Sur, sobre el papel que juegan los moluscos y otros invertebrados en la transmisión de *Angiostrongylus cantonensis* al hombre, mostraron que varios caracoles, babosas y una planaria que se encuentran en los huertos que suplen gran cantidad de legumbres frescas a los mercados locales, estaban generalmente infectados con larvas de *A. cantonensis* de tercer estadio. Los veronicélidos *Vaginulus plebeius* y *Laevicaulus alte* fueron los moluscos más frecuente e intensivamente infectados y aparentemente sirven de reservorio principal de la infección en ratas silvestres. El alto nivel de infección en estas babosas no sólo mantiene una alta prevalencia de ratas infectadas, sino que es también importante en la dispersión de las larvas infectantes entre las planarias, huéspedes paraténicos del parásito. Aparentemente no hay variación estacional en la tasa y nivel de infección en las babosas, pero sí tienen un período de reposo durante los meses más fríos del año (julio a setiembre). Probablemente las planarias constituyen el grupo más importante como fuente de infección humana en Nueva Caledonia. Estas planarias son más abundantes durante los meses más fríos, época en que se produce la mayor cantidad de legumbres. Sus hábitos altamente carnívoros, particularmente en sus ataques a los caracoles y babosas, contribuyen al alto nivel de infección, aunque individualmente las planarias albergan números relativamente bajos de larvas, generalmente menos de 10. Su reducido tamaño, la facilidad que tienen para fragmentarse y su rápida deshidratación, para formar masas negras inconspicuas que contaminan las lechugas y otras hortalizas, las hacen el vehículo ideal para la transmisión de *A. cantonensis* al hombre.

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