HELMINTH PARASITE COMMUNITIES IN FOUR SPECIES OF SHOREBIRDS (CHARADRIIDAE) ON KING ISLAND, TASMANIA

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(with six tables and three text-figures)

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Helminth community composition and structure were examined among two resident shorebird species, red-capped plover, *Charadrius ruficapillus* (N = 20), and masked lapwing, *Vanellus miles* (N = 5), and two migrants, ruddy turnstone, *Arenaria interpres* (N = 20), and curlew sandpiper, *Calidris ferruginea* (N = 5), on King Island, Tasmania in March–April 1993, prior to northward migration to the nesting grounds. The total number of species of helminths recovered was 28 and life cycles of at least 19 of these were occurring on the island. Twenty-five species were categorised as generalists and three were undetermined. One to three species of helminths were dominant in each host species. Eight species, to various degrees, were common among the four species of host. Most sharing occurred in the mucosal trematode guild. Similarities between resident *Charadrius ruficapillus* and migrant *A. interpres* was 32.7%, while the mean number of species and mean number of helminths were significantly higher in *A. interpres*. Except for five new species found in this study, all other species of helminths have been described or reported from charadriids or related hosts from other continents. The pool of helminth parasites capable of infecting shorebirds was well established on King Island.
Key Words: helminth parasites, shorebirds, Charadriidae, *Arenaria interpres*, *Calidris ferruginea*, *Charadrius ruficapillus*, *Vanellus miles*, King Island, Tasmania.

INTRODUCTION

Tasmania and its adjacent islands provide significant habitat to wintering migrant shorebirds (Charadriidae), most of which breed in the Northern Hemisphere, and non-migrating resident shorebirds. King Island, located off the northwest coast of the Tasmanian mainland (40°S, 144°E; 58 km long by 21 km wide), is utilised by and is important habitat for both groups of shorebirds (Schulz 1990). Two migrants, ruddy turnstone, *Arenaria interpres* Linnaeus, and curlew sandpiper, *Calidris ferruginea* Pontoppidian, and two residents, red-capped plover, *Charadrius ruficapillus* Temminick, and masked lapwing, *Vanellus miles* Boddart, were common on King Island at the time of the study (February–March 1993). Ruddy turnstones breed on the coastal plain or lowlands around the Arctic Ocean. They feed on marine invertebrates in rocky areas, on reefs exposed at low tide and in sandy areas with deposits of seaweed. Curlew sandpipers breed mostly on high altitude tundra in Central Siberia and some in northern Alaska. Their preferred foraging areas for invertebrates are muddy areas, including intertidal mudflats (Hayman *et al.* 1986). Masked lapwings breed on King Island and prefer open areas with low vegetation, such as pastures and grasslands (Green 1989, Hayman *et al.* 1986, Slater *et al.* 1989). Some were observed foraging in the intertidal zone at low tide (AGC). Red-capped plovers also breed on King Island (Green 1989, Slater *et al.* 1989) and were observed mostly on open ocean sandy beaches, sandy patches between rocky areas and in areas with deposits of seaweed (AGC).

Many wader species throughout the world have been subjected to diminished and altered habitat. As environmental change continues, overcrowding and stress, factors known to alter host–parasite relationships (Esch *et al.* 1975, Friend 1992), will probably increase. To detect changes in these relationships and their effect on avian morbidity and mortality, analyses of parasite community composition and structure are necessary to establish norms.

Smith (1974, 1983), working in southern Tasmania, elucidated several helminth life cycles and described several species of helminths which used charadriids as definitive hosts. Deblock & Canaris (1996, 1997) described several new species of helminths from charadriids from King Island, Tasmania, from material gathered for the study recorded here.

The purpose of this study is to examine and compare the helminth parasite community composition and structure among two resident and two migrant waders from King Island. Comments on changes in helminth communities over time and migration are included.

We chose to study these four species of hosts because they were common components of the shorebird community, utilising differing habitats but with possible overlap during foraging, and because nothing was known about helminth communities in Charadriidae from King Island.

MATERIAL AND METHODS

Populations of two species of resident waders, *Charadrius ruficapillus* (N = 20) and *Vanellus miles* (N = 5), and two of migrants, *Arenaria interpres* (N = 20) and *Calidris ferruginea* (N = 5), were collected on King Island, Tasmania, from 26 February to 8 March 1993. Birds were taken under permit, placed immediately in individual plastic bags, refrigerated and examined within six hours. Acanthocephalans, cestodes and trematodes were fixed in alcohol-formalin-acetic acid (AFA), stained in Semichon's acid carmine or Ehrlich's hematoxylin, cleared in clove oil and mounted in Canada balsam. Nematodes were fixed and preserved in 70% ethanol and examined in temporary lactophenol mounts. Voucher specimens were deposited in the University of Nebraska State Museum, Parasitology Division, Harold W. Manter Laboratory HWML39356 to 39460 and in the Invertebrate Zoology Department, Tasmanian Museum K1679 to 1693.

Two software statistical programs were utilised to analyse the data; NCSS, 329 N. 1000 E., Kaysville, Utah, USA, and Oakleaf Systems, PO Box 472, Decorah, Iowa, USA. The following statistical procedures were used to define the component helminth community (composition and structure) and to compare communities between *C. ruficapillus* and *A. interpres*:

- the Martinez-Inglewicz and D'Agostino Omnibus tests for normalcy;
- two sample t-tests for number of species of helminths (normal data with equal variances);
- Aspen-Welch test for number of helminths (normal data with unequal variances);
- Mann-Whitney-*U* test to test for J' values (non-normal data with equal variances);
- Kruskal-Wallis test for changes in helminth numbers from the same collecting site over time, and number of species of helminths and number of helminths among migratory charadriids;
- variance to mean ratio test (S^2/X with X^2 goodness-of-fit test) for dispersion (uniform-random-contagious) for each species of parasite, and for the number of species of parasites and number of parasites of the population using the total from each host;
- Shannon's index for diversity (Pielou's J'), in which a J' value was calculated for each host and these values were summed and total mean J' values for the populations were derived (the closer the J' values were to 1.00, the more evenly the helminths were distributed among the hosts);
- Morisita's index of similarity, Jaccard's coefficient of similarity and percent similarity to evaluate community similarity between the above two species of hosts (the closer the values to 1.00 the greater the similarity);
- X-abundance and graphical analysis (by plotting helminth prevalence [X] versus percent of total [Y] for each species of helminth and observing the position and relationship of individual species to all others) to define the dominant species of helminth communities; and lastly,
- the X^2 statistic with Cole's coefficient and Spearman's rank correlation coefficient for interspecific association analysis.

Infracommunity composition and structure of helminths was examined by dividing the gastrointestinal tract into the following sections: oral cavity, oesophagus, proventriculus, ventriculus; small intestine into equal thirds beginning from the most anterior, paired caeca, large intestine and cloaca. All other internal organs and the body cavity were also examined. Parasite guilds were investigated using the following classifications proposed by Bush & Holmes (1986) and Bush (1990):

(1) trematode guild — mucosal, feed by engulfing gut tissue and by absorbing nutrients across the body surface;
(2) luminal absorbers — large cestodes and all acanthocephalans, attached to the mucosa but bodies are luminal, feed strictly by absorbing materials across the body surface;
(3) mucosal absorbers — small cestodes intimately associated with the mucosa;
(4) nematode guild — mucosal, feed strictly by engulfing gut tissue or contents.

Helminth specialists and generalists were categorised using the following criteria: specialists — those helminth species that either have the bulk of reproducing adults found only in a single host species or have been reported from a single host species, and generalists — found or reported from several host species, including hosts from other regions (Edwards & Bush 1989, Bush 1990, Hinojos *et al.* 1993). For applicable statistical tests, significance was assumed when P 0.05. Statistical tests of data for parasite communities of *C. ferruginea* and *V. miles* were limited because of small numbers examined. Abbreviations used were: X = mean of the population; SD = standard deviation; M = median of the population; R = range; GI = gastrointestinal; SI = small intestine; T, L, M, N, Tis = respective guilds — trematode, luminal absorber, mucosal absorber, nematode, and tissue other than GI tract.

RESULTS

Red-capped plover *C. ruficapillus* (N = 20)

A total of 1458 helminth parasites (X abundance = 72.9, SD = 60.7, M = 50.0) consisting of 13 species (X = 3.6, SD = 1.1, M = 3.0) was collected from this host. The parasite population in the community was normally distributed (P < 0.05), and the parasites were fairly evenly distributed among the hosts (J' = 0.69). The number of species of parasites was also normally distributed (P < 0.05) and was uniform in dispersion ($S^2/X = 0.33$, P < 0.01). All hosts were infected with at least one species of helminth (R = 1–6 species), and after host #14 only one additional species was observed that had not been observed previously. Among the helminths, eight species of trematodes, four of cestodes and one of acanthocephalans were represented. Two trematodes, *Levinseniella howensis* and *Maritrema eroliae,* and a cestode, *Proterogynotaenia* sp., were the most prevalent and abundant parasites. They accounted for 77.4% of the total number of parasites and were considered the dominant species in the community (table 1). All species of parasites were contagious (clumped or aggregated) with respect to dispersion (P < 0.01 for each species). There was a positive association between infections of *L. howensis* and *Proterogynotaenia* sp. (+0.72). A less pronounced association, one positive and one negative, occurred between *L. howensis* and *Hymenolepis lauriei* (+0.57) and between *Proterogynotaenia* sp. and *H. lauriei* (–0.47). Expected frequencies were too small to use the Chi-square statistic for the above associations. Four species of trematodes were new to science and have been described recently; *Maritrema spinosulum, Microphallus pearsoni, M. pseudogonotylus* and *Rhynchostophallus insularegii* (Deblock & Canaris 1996, 1997). The cestode *Proterogynotaenia* sp. is a new species now being described.

Ruddy turnstone *A. interpres* (N = 20)

A total of 3656 helminth parasites (X abundance = 182.8, SD = 156.3, M = 141) consisting of 14 species (X = 5.2, SD = 1.2, M = 5.0) was collected from this host. The parasite population in the community was normally

TABLE 1
Helminths of the red-capped plover *Charadrius ruficapillus*, King Island, Tasmania (N = 20)

Helminths*	Prevalence	Abundance		Range	Total	% of total
	%	mean	SD			
Trematoda						
Acanthoparyphium charadrii Yamaguti, 1939 T	15	1.0	3.38	1–15	19	1.3
Levinseniella howensis Johnston, 1916 T	70	11.9	21.64	2–90	238	16.3
L. monodactyla Deblock and Pearson, 1970 T	15	4.7	14.04	15–60	94	6.5
Maritrema eroliae Yamaguti, 1939 T	60	15.4	34.46	1–136	308	21.1
M. spinosulum Deblock and Canaris, 1996 T	5	0.4	1.79	–	8	0.6
Microphallus pearsoni Deblock and Canaris, 1997 T	20	1.6	4.51	1–17	31	2.1
M. pseudogonotylus Deblock and Canaris, 1997 T	25	1.3	3.34	1–14	26	1.8
Rhynchostophallus insularegii Deblock and Canaris, 1997 T	5	0.2	0.89	–	4	0.3
Cestoidea						
Aploparaksis leonovi Spasskii, 1961 L	5	0.2	0.67	–	3	0.2
Nadejdolepis lauriei (Davies, 1939) M	15	5.6	16.20	15–67	112	7.7
N. mudderbugtenensis (Baer, 1956) M	15	0.6	2.08	1–9	13	0.9
Proterogynotaenia sp. L	85	29.1	39.68	2–149	582	40.0
Acanthocephala						
Plagiorhynchus charadrii Yamaguti, 1939 L	25	0.1	2.97	1–13	20	1.4

* Guilds: T = trematode; L = luminal absorber; M = mucosal absorber.

distributed ($P < 0.05$) and the parasites fairly evenly distributed among the hosts (J' = 0.69). The number of species of parasites was also normally distributed ($P < 0.05$) and was uniform in dispersion ($S^2/X = 0.22$, $P < 0.01$). All hosts were infected (R = 3–7 species), and after host #12 no additional species were observed that had not been observed previously. Among the helminths, six species of trematodes, seven of cestodes and one of acanthocephalans were represented. The three most prevalent and abundant helminths were the trematodes *Maritrema eroliae,* and *L. howensis,* and the cestode *Trichocephaloides megalocephala.* They accounted for 76.6% of the total number of parasites and were considered the dominant species in the community (table 2). All species of parasites were contagious with respect to dispersion ($P < 0.01$ for each species except for *Arythmorhynchus tringi,* which was random, $P < 0.05$). No positive or negative associations between species of parasites were detected. Of the four recently described helminths from King Island shorebirds (Deblock & Canaris 1996, 1997), only *M. pearsoni* was observed in this host.

Curlew sandpiper *C. ferruginea* (N = 5)

A total of 154 helminth parasites (X abundance = 30.8, M = 13) consisting of five species (X = 1.8, M = 2) was collected from this host. Four of the five hosts were infected with at least one species of parasite (R = 1–4). Among the helminths, four species of cestodes and one of trematode were represented. The cestode *Nadejdolepis paranitidulans* was the most prevalent and abundant helminth. It accounted for 87.0% of the total number of parasites and was the dominant species (table 3).

Masked lapwing *V. miles* (N = 5)

A total of 282 helminth parasites (X abundance = 56.4, M = 9) consisting of nine species (X = 2.8, M = 3) was collected from this host. All five of the hosts were infected with at least one species of parasite (R = 1–4). Among the helminths, four species of cestodes, two of nematodes, one of trematode and two of acanthocephalans were represented. The cestode *N. lauriei* and the nematode *Porrocaecum heteroura* were the most prevalent. The cestode *Anomotaenia microrhyncha* was the most abundant, accounting for 82.6% of the total number of parasites, and was the dominant species (table 4).

Parasite guilds

The trematode guild was predominant in the resident red-capped plover *C. ruficapillus* with eight species and 50% of the helminth abundance. A luminal absorber, the cestode *Proterogynotaenia* sp., was very high in prevalence (85%) and abundance (40%) (table 1). The trematode guild was also predominant in the migratory ruddy turnstone, *A. interpres,* with six species and 67.2% abundance. One luminal absorber, the cestode *T. megalocephala,* was also very prevalent (95%) and abundant (22%) (table 2).

Mucosal absorbers were predominant in the small sample of migrant curlew sandpipers, *C. ferruginea* ,with the cestode *N. paranitidulans* being the most prevalent (60%) and abundant (83%) (table 3). Luminal absorbers were the predominant guild in the resident masked lapwing *V. miles.* This was the only species of host that showed a mix of both terrestrial and marine-associated helminths and harboured the nematode guild.

TABLE 2
Helminths of the ruddy turnstone *Arenaria interpres*, King Island, Tasmania (N = 20)

Helminths*	Prevalence %	Abundance mean	Abundance SD	Range	Total	% of total
Trematoda						
Echinostephilla virgula Lebour, 1909 T	45	2.1	3.75	1–15	42	1.2
Gynaecotyla macrocotylata Smith, 1983 T	25	7.9	19.28	1–77	158	4.3
Levinseniella howensis T	100	16.4	19.44	1–66	328	9.0
L. monodactyla T	15	0.5	1.23	2–5	9	0.3
Maritrema eroliae T	70	88.4	105.34	2–355	1767	48.3
Microphallus pearsoni T	15	7.6	13.15	3–46	151	4.1
Cestoidea						
Anomotaenia skrjabini Ginetsinskaya and Naumov, 1958 L	40	5.1	8.97	1–28	101	2.6
A. clavigera (Krabbe, 1869) L	15	6.0	17.44	0–73	119	3.3
Aploparaksis leonovi L	25	1.5	3.19	2–10	30	0.8
Dicranotaenia amphitricha (Rudolphi, 1819) M	5	0.4	1.57	–	7	0.2
Nadejdolepis nitidulans (Krabbe, 1882) M	35	7.6	26.18	2–118	152	4.2
Ophryocotyle proteus Friis, 1870 M	10	0.7	2.06	5–8	13	0.4
Trichocephaloides megalocephala (Krabbe, 1869) L	95	38.9	44.04	1–150	778	21.3
Acanthocephala						
Arythmorhynchus tringi Gubanov, 1952 L	5	0.1	0.22	–	1	0.03

* Guilds as table 1.

TABLE 3
Helminths of the curlew sandpiper *Calidris ferruginea*, King Island, Tasmania (N = 5)

Helminths*	Prevalence (no. infected)	Mean abundance	Range	Total	% of total
Trematoda					
Acanthoparyphium charadrii T	2	1.6	3–5	8	5.2
Cestoidea					
Anomotaenia microrhyncha L	1	0.2	–	1	0.7
Echinocotyle dubininae M	1	0.4	–	2	1.3
Nadejdolepis paranitidulans (Golikova, 1959) M	3	26.8	11–62	134	87.0
Ophryocotyle proteus M	2	1.8	3–6	9	5.8

* Guilds as table 1.

TABLE 4
Helminths of the masked lapwing Vanellus miles from King Island, Tasmania (n = 5)

Helminths*	Prevalence (no. infected)	Mean abundance	Range	Total	% of total
Trematoda					
Brachylaima fuscatum Rudolphi, 1819 T	1	4.2	–	21	7.5
Acanthoparyphium charadrii T	1	0.6	–	3	1.1
Cestoidea					
Anomotaenia microrhyncha Krabbe, 1869 L	2	46.6	6–227	233	82.6
Chitinorecta agnosta Megitr, 1927 M	1	0.2	–	1	0.4
Nadejdolepis lauriei M	3	2.4	3–6	12	4.3
Nematoda					
Heterakis sp. N	1	0.2	–	1	0.4
Porrocaecum heteroura Creplin, 1829 N	3	1.4	2–3	7	2.5
Acanthocephala					
Plagiorhynchus gracilis Petrochenko, 1958 L	1	0.4	–	2	0.7
Plagiorhynchus sp. L	1	0.4	–	2	0.7

* Guilds as table 1; N = nematode.

Host specialists and generalists

The total helminth pool consisted of 28 species, and at least 25 were generalists, in that all have been reported from other birds. Two trematodes, *M. pseudogonotylus* and *R. insularegii,* and the cestode *Proterogynotaenia* sp. may be specialists in *C. ruficapillus* but we do not know enough about host–parasite relationships and geographic distribution in Tasmania to categorise them. Eight helminth species were recovered from at least two species of host, and *Acanthoparyphium charadrii* infected three species of host. The largest number of shared species came from the trematode guild, and there were none from the nematode guild (table 5). The life cycles of at least 19 species of helminths were occurring in their entirety on King Island, because all infections in resident hosts were the result of ingesting infected food items from the local habitat. Life cycles of microphallids, which are short-lived as adults, may also be occurring locally. For example, the microphallid *L. howensis* was observed emerging from the metacercarial cysts harboured by gammarids ingested by *A. interpres.*

Infracommunity

Most species of helminths were in largest numbers in a specific section of the GI tract. The largest number of helminths was recovered from the anterior third of the small intestine in *C. ruficapillus* and the middle third in *A. interpres* (fig. 1). The paired caeca in both species of host were the site of choice for the trematode *L. howensis.* In both *C. ruficapillus* and *A. interpres,* the three dominant species of helminths, in general, were in greatest abundance in different sections of the GI tract. This was most evident for the two species of cestodes and the trematode *L. howensis* (figs 2, 3). We could not determine if any particular section was saturated (packed), although some species did extend in smaller numbers into adjacent sections of the small intestine. Most parasites recovered from the large intestine and cloaca were unhealthy in appearance or moribund.

Community comparison, *C. ruficapillus* vs *A. interpres*

There were five species of helminths which infected both species of host with a similarity of 32.7% (Morisita's index = 0.44; Jaccard's coefficient = 0.23). The mean number of species and mean number of helminths were significantly higher in *A. interpres* ($P < 0.00001$ and $P < 0.01$ respectively). Evenness of distribution of parasites for the two species of hosts was not very different ($J' = 0.69$ vs 0.69; $P > 0.06$). Over a five-day period, helminth numbers increased significantly for the combined three dominant species *L. howensis, M. eroliae* and *T. megalocephala* in *A. interpres* ($P < 0.001$), but not overall, and helminths decreased significantly overall for *C. ruficapillus* ($P < 0.05$).

DISCUSSION

Helminth Regional Relationships

The pool of helminth parasites on King Island infecting charadriids is well established and, as indicated by infections in the non-migratory host species, many of the life cycles occur in the area. Two species of the helminths observed in our study, *Gynaecotyla macrocotylata* and *M. eroliae,* were reported from southern Tasmania by Smith (1983). He also described three species of microphallid trematodes from the same general locality: *Atriophallophorus coxiellae* from *Charadrius cucullatus* Vieillot and *C. ruficapillus*; *Maritrema calvertensis* from *C. cucullatus* and *Charadrius melanops* Vieillot; and *Microphallus tasmaniae* from *C. cucullatus, C. melanops* and *C. ruficapillus* (Smith 1974). None of these three parasites was observed in our study. Three species of microphallids observed in our study have been reported or described from shorebirds on or near the Australian mainland, *Maritrema eroliae* in *C. mongollus* Pallas and *Calidris acuminata* Horsefield from Queensland (Deblock & Pearson 1968, Deblock & Canaris 1996), and *Levinseniella monodactyla* in *Charadrius mongollus* from Queensland (Deblock & Pearson 1970) and *L. howensis* in *Pluvialis*

TABLE 5
Abundance of shared helminths among four species of shorebirds, King Island, Tasmania

Helminths*	*Charadrius ruficapillu*	*Arenaria interpres*	*Calidris ferruginea*	*Vanellus miles*
Acanthoparyphium charadrii T	1.0	–	1.6	0.6
Levinseniella howensis T	11.9	16.4	–	–
L. monodactyla T	4.7	0.5	–	–
Maritrema eroliae T	15.4	88.4	–	–
Microphallus pearsoni T	1.6	7.6	–	–
Anomotaenia microrhyncha L	–	–	0.2	46.6
Aploparaksis leonovi L	0.2	1.5	–	–
Nadejdolepis lauriei M	5.6	–	–	2.4

* Guilds as table 1.

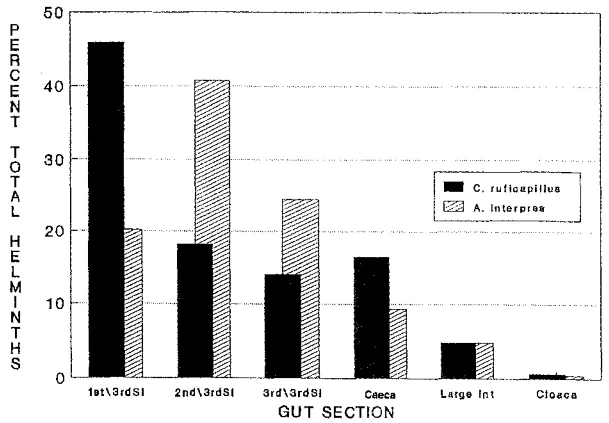

FIG. 1 — Distribution of helminths in the gastrointestinal tract of Charadrius ruficapillus *and* Arenaria interpres, *King Island, Tasmania*

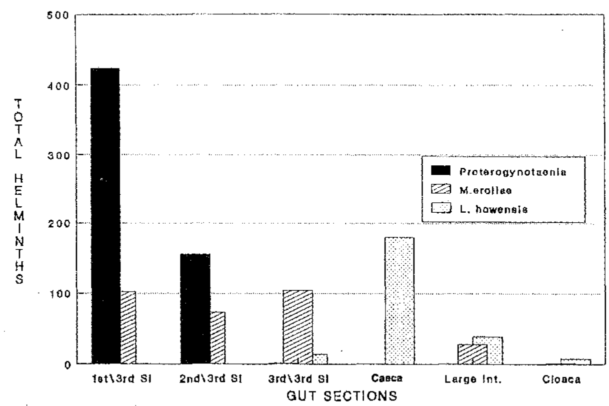

FIG. 2 — Distribution of three dominant helminth species in the gastrointestinal tract of Charadrius ruficapillus, *King Island, Tasmania*

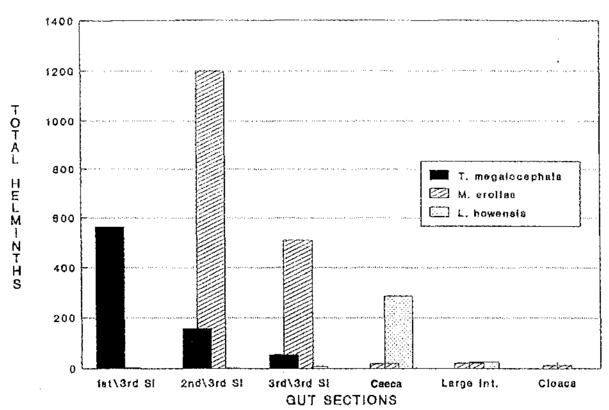

FIG. 3 — Distribution of three dominant helminth species in the gastrointestinal tract of Arenaria interpres, *King Island, Tasmania*

dominica Müller from Lord Howe Island (Pearson & Deblock 1979). Microphallids are predominantly marine and short-lived, and appear to be mostly regional. It is unlikely any of the Australian and Tasmanian species will be found in other regions. One exception may be *M. eroliae* but, according to Deblock & Canaris (1992, 1996), it appears to be a species-complex. Mawson (1968) reported nematodes from 20 species of waders, mostly from South Australia, but none of these parasites was observed in our study. All other helminth species reported here, except for the five new species, have been described or reported from charadriids or related species from other continents (Eurasia, North and South Americas).

Helminth Distributions and Relationships

Contagious (clumped) distributions of helminths as observed in *A. interpres* and *C. ruficapillus* appear to be typical for shorebirds. A summary of possible causes for contagious distribution gleaned from literature by Secord & Canaris (1993) are as follows: genetic variability within the host population, host susceptibility, host behavioural and social traits, individual feeding habits, spatial location of helminths and intermediate hosts, and chance distribution of infective stages. The strong positive relationship between the trematode *L. howensis* and the cestode *Proterogynotaenia* in *C. ruficapillus* may be the result of both parasites utilising the same intermediate host. The other two helminth relationships in this host, one positive and one negative, are not very strong and may be influenced by sample size.

Helminth Community Changes

Parasite communities in shorebirds may change over time. This appeared to be happening during the relatively short period of this study. Increase in helminths in *A. interpres* during the latter part of the study was coincidental with ingestion of gammarids infected with metacercariae of *L. howensis* and with enhanced fat deposits in preparation for migration. Both observations of increase of helminths in *A. interpres* and decrease in the resident *C. ruficapillus* need to be studied over a longer time-period with increased sample size before we consider these observations definitive.

Ginetsinskaya (1953) compiled data from 12 shorebird–helminth studies (N = 1539 birds) done in various regions of the USSR. Based on the number of hosts infected with the four major helminth groups, trematodes, cestodes, nematodes and acanthocephalans, she concluded cestodes were predominant in ten of the 12 studies. Trematodes were predominant in two, both from the maritime littoral zone, and most species of acanthocephalans observed were also from this zone. She also stated that the number of worm species, both overall and within each helminth group, was markedly higher on the nesting grounds than in migrating birds. She attributed the loss of parasites in migration to a seasonal decrease in invertebrates, which act as intermediate hosts, and losses of short-lived parasites, particularly trematodes. Bush (1990) examined willets, *Catoptrophorus semipalmatus* Gmelin, from nesting grounds (freshwater) in Canada and wintering grounds (marine) in the USA and reported no significant difference in number of species of helminths but a significantly higher number

TABLE 6
Summary of selected data from 17 shorebird studies

Host*	Species richness	Mean abundance	Most abundant group– % of total	Guilds present†	Locality	Reference
(1) Western sandpiper-Mig (*Calidris mauri*) N = 50, autumn–spring, freshwater	5	1.1	cestode–77.4	T-1,L-4	SW Texas	Canaris & Munir 1991
(2) Greater yellowlegs-Mig (*Tringa melanoleuca*) N = 48, autumn–spring, freshwater	9	25.9	cestode–82.3	T-3, L-2, M-2, TisT-2	SW Texas	Secord & Canaris 1993
(3) Wilson's phalarope-Mig (*Phalaropus tricolor*) N = 100, autumn–spring, freshwater	12	8.3	cestode–63.5	T-5, L-4, M-1, TisT-2	SW Texas	Yanez & Canaris 1988
(4) Common snipe-Mig (*Capella gallinago*) N = 60, autumn–spring, freshwater	14	12..2	nematode–46.1	T-3, L-8, N-3	SW Texas	Leyva *et al.* 1980
(5) Dunlin-W (*Calidris alpina*)						
A. N = 28, Oct.–Apr., marine	26	254.2	cestode–50.2	T-8, L-9, M-5, N-3, TisN-1	Ireland	Cabot 1969
B. N = 27, Feb. & Mar., marine	17	291.3	cestode–97.0	T-6, L-8, M-2, N-1	California	Ching 1990
(6) Willet 37 (*Catoptrophorus semipalmatus*)						
A. N = 46, June, freshwater-Nes	3	62.3	cestode–59.2	T-14, L-12, M-9, N-2	Alberta, Manitoba	Bush 1990
B. N = 9, Jan., marine-W	11	618.2	trematode–99.0	T-7, L-2, 2?	California	Ching 1990
C. N = 30, Jan.–Feb., marine-W	34	723.3	trematode–91.3	T-22, L-6, M-3,N-3	Florida, Louisiana	Bush 1990
(7) American avocet (*Recurvirostra americana)*						
A. N = 22, May–June, freshwater-Nes	41	3,727	cestode–92.5	T-8, L-10, M-17,N-5, TisT-1	Alberta, Manitoba	Edwards & Bush 1989
B. N = 33, autumn-spring, freshwater-MN	19	220.2	cestode–88.8	T-8, L-3, M-2, N-2, TisT-3	SW Texas	Garcia & Canaris 1987
C. N = 60, July–Sep., freshwater-Nes	6	79.5	cestode–91.6	L-4, M-1, TisT-1	Utah	Hinojos *et al.* 1993
(8) Black-necked stilt-MN (*Himantopus mexicanus*) N = 35, autumn–spring, freshwater	19	162	cestode–83.2	T-3,L-4, M-3, N-6, TisN-1, TisT-2	SW Texas	Hinojos & Canaris 1988
(9) Long-billed curlew-Nes (*Numenius americana*) N = 18, June, freshwater	9	318	cestode–99.0	T-1, L-8	Alberta	Goater & Bush 1988
(10) Ruddy turnstone (*Arenaria interpres*)						
A. N = 6, Oct.–Apr., marine-W	11	172.3	cestode–50.0	T-4, L-4, M-1, N-1, TisT-1	Ireland	Cabot 1969
B. N = 20, Feb.–Mar., marine-W	14	182.8	trematode–67.2	T-6, L-5, M-3	Tasmania	This study
(11) Red-capped plover (*Charadrius ruficapillus*) N = 20, Feb.–Mar., marine, resident	13	72.9	trematode–49.9	T-8, L-3, M-2	Tasmania	This study

* Mig = migrating; W = wintering; Nes = nesting; MN = mostly migrating, but some nesting occurs in the area.
† Guilds as before; Tis = tissue.

of helminths on the wintering grounds. Cestodes were in highest abundance on the nesting grounds and trematodes on wintering grounds (table 6).

OBSERVATIONS

We compiled data from 17 studies, including this one, on 11 species of shorebirds (N = 612) from both freshwater and marine habitats (table 6). Cestodes were the most abundant in all 12 freshwater habitats, trematodes in four marine habitats, and nematodes in one, the more terrestrial common snipe *Gallinago gallinago* Linnaeus. Trematode and luminal guilds were represented by the largest numbers of occurrences (107 and 96 respectively) followed by mucosal guilds (51), and nematodes (26). We added a tissue guild (= Tis) for helminths occupying others organs or cavities. However, not all of the above studies include this guild. We also placed hosts in one of four groups. With respect to mean number of species the results were 23 nesting birds, 10 migrating, 19 migrating with some nesting and 19 wintering. Although there was no significant difference ($P > 0.05$), the same observation reported by Ginetsinskaya (1953) of migrating shorebirds having the fewest species is also attendant in our data. We also examined mean abundances as above with the following results; 1122, 12, 191 and 374. There was a significant difference ($P < 0.05$) with the migrating shorebirds having the fewest helminths. We present these observations with caution, because each migrant species needs to be examined throughout its range before we can be sure about the dynamics of helminth communities under these differing biotic and abiotic circumstances.

We assume that additional studies of helminth communities of waders from Tasmania would reveal new species, because of geographic isolation, availability of non-migrating charadriids as hosts and the established presence of helminths whose adult stages are short-lived, as in the Microphallidae. Finally, we expect additional commonality of helminths among species of hosts in Tasmania and Australia and, because many species of charadriids migrate to and from this region, additional affinity of some helminths with charadriids from other continents.

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