

Parasitological Society of Southern Africa

The following are abstracts of papers presented at the Annual Scientific Meeting of the Society held at Onderstepoort on 7 and 8 July 1981.

Parasitologiese Vereniging van Suidelike Afrika

Die volgende is uittreksels van referate wat gedurende die Jaarlikse Wetenskaplike Vergadering van die Vereniging vanaf 7 tot 8 Julie 1981 te Onderstepoort gehou was.

Long-term Cryopreservation of Nematode Larvae in Liquid Nitrogen

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Infective larvae, which have been exsheathed in sodium hypochlorite, are frozen by immersion in the gas phase of liquid nitrogen. Before use the larvae are thawed quickly in warm water.

When 3rd stage larvae (L3) of *Haemonchus contortus*, *Ostertagia circumcincta*, *Trichostrongylus axei*, *Trichostrongylus colubriformis*, *Nematodirus spathiger*, *Oesophagostomum columbianum* and *Chabertia ovina* of sheep and *Haemonchus placei*, *Ostertagia ostertagi*, *Cooperia* spp. (*C. pectinata* and *C. punctata*), *Nematodirus helvetianus* and *Oesophagostomum radiatum* of cattle were thawed after 52–59 months of cryopreservation, 90.3% of them were alive.

These L3 as well as those of *Marshallagia marshalli* and *Trichostrongylus falculatus*, which had been frozen for 30–33 months, were infective to sheep or cattle when dosed *per os* or inoculated into the abomasum or the duodenum. Thawed *Dictyocaulus filaria* L3, frozen for 31 months, developed poorly when injected intravenously into sheep. The two hookworm species *Gaigeria pachyscelis* and *Bunostomum phlebotomum*, and the white bankrupt worm, *Strongyloides papillosus*, however, were not infective after freezing.

Repeated freezing of consecutive generations of L3 of a strain of *Haemonchus contortus* relatively resistant to benzimidazole anthelmintics did not appear to affect the resistance of the offspring to these remedies.

Anatrichosoma sp. Infestation in the Footpads of a Cat

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A nematode of the genus *Anatrichosoma* caused extensive necrosis and sloughing of the footpads of a domestic cat. Initially there was severe exudation with matting of the hair between the toes and on the feet. The epidermis of the footpads became detached from the underlying tissue and eventually sloughed completely, leaving a raw surface. Adult female worms were seen partially imbedded in the sloughed epidermis. The necrosis and sloughing probably occurred as a result of the migration of the worms under the epidermis.

The female worms recovered were typical of the genus *Anatrichosoma*, in that they had a cephalic inflation, a post-oesophageal swelling and bioperculate eggs, but they differed from the previously described species which occur in primates.

This is the first report of *Anatrichosoma* sp. in South Africa as well as the first record in a cat.

Some Arthropods Parasitic on Freshwater Fish

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Of the arthropods parasitic on fish, the Crustacea are probably the most important particularly those belonging to the subclasses Copepoda and Branchiura, which are certainly the most abundant and pathogenic ectoparasites.

The subclass Copepoda consists of about 20 families, all of which have undergone modifications as adaptations to a parasitic mode of life. These adaptations include changes to the head appendages to act as organs of attachment, and the incorporation into the head of one or more thoracic

segments, a process known as cephalization. In addition, diphasic growth, where the head and holdfast first increase in size, followed by growth of the rest of the body, is seen in these parasites.

Some primitive Copepods, such as *Bomolochus* sp., are clearly segmented and show few modifications to parasitism. In the metamorphosed genera, such as *Lernaea*, cephalization has taken place to such an extent that the animal which lives mainly under the fish's scales, consists of little more than a holdfast and reproductive organs. *Lamproglanoides* is a genus recently found in South Africa that lives on the gills of various fish species and is only a little less modified than *Lernaea*.

The subclass Branchiura includes *Argulus* spp. that are capable of transmitting certain fish diseases by means of their piercing mouthparts. Two other members, *Dolops* and *Chonopeltis*, have also been found on South African freshwater fish. Because neither has piercing mouthparts, they cannot transmit infectious diseases, although they are highly irritative. All of the Branchiuran parasites are potentially dangerous in production units, and may cause losses through exsanguination (*Argulus*), transmission of diseases (*Argulus*) or decreased growth as a result of irritation (*Dolops* and *Chonopeltis*).

Identification of *Theileria taurotragi* in South Africa

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Since its isolation in 1906, *Theileria mutans* was for many years recognised as the only benign bovine *Theileria* sp. in South Africa. The vector was assumed to be *Rhipicephalus appendiculatus*, based on observations, amongst others, made by Theiler in 1909. It has, however, now been shown conclusively that the vector of *T. mutans* in this country is *Amblyomma hebraeum* and not *R. appendiculatus*.

A second benign *Theileria* sp. infective for cattle was recently isolated from adult *R. appendiculatus* collected in the field and was subsequently identified as *Theileria taurotragi*. From the literature it is clear that this species has been encountered repeatedly by workers in South Africa since 1909, but was evidently confused with *T. mutans*.

A distinguishing feature of the two species is that *T. mutans* can readily be transmitted by the subinoculation of blood, while this is not so in the case of *T. taurotragi*. The two species are serologically distinct.

Influence of Age, Sex and Breed on Naturally-acquired Bovine Parafilariosis

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A total of 1693 cattle carcasses from an area in South Africa in which parafilariosis is enzootic were examined macroscopically in December 1980 for the presence of lesions due to *Parafilaria bovicola*; 51.5% were positive. In as many cases as possible, the number of lesions per carcass was counted, their size was measured, and they were trimmed from the carcass and hide and incubated in saline for recovery of worms.

Overall, cows had fewer worms and lesions, a smaller mean lesion size and smaller mean affected carcass area than steers. Likewise steers were less severely affected than bulls. Age-analysis of the data gave the sources of these differences. Young cows (0–4 permanent incisors) had a lower lesion prevalence than young steers but not lower than young bulls. Older bulls (6 & 8 permanent incisors) had much higher prevalence rates than both old cows or steers, which did not differ significantly from each other. The Afrikaner breed had a higher lesion prevalence than the Brahman. No dif-

ferences were found between light and dark-coloured Brahmans.

The possible hormonal, behavioural and genetic factors which may contribute to the observed differences were discussed.

Seasonal Incidence of Nematodes in the Burchell's Zebra (*Equus burchelli*)

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A total gastrointestinal nematode study was made of ten male Burchell's zebras from the Kruger National Park, South Africa. This investigation included total worm burdens and seasonal incidence. Four colts and six stallions were collected at intervals of two months over an eleven-month period. The nematodes recovered included the Atractidae, Cyathostominae, Spiruridae and the Strongylinae. The Atractidae (*Crossocephalus*, *Probstmayria*) and the Strongylinae (*Strongylus*, *Craterostomom*, *Oesophagodontus*, *Triodontophorus*) were top of the range in the stallions (age 2 – 23 years) with 24 206 815 and 2718 respectively, while the Cyathostominae (*Cyathostomum*, *Cylicocyclus*, *Cylicodontophorus*, *Cylicostephanus*, *Cylindropharynx*, *Poteriostomum*) and Spiruridae (*Draschia*, *Habronema*) carried the top of the range in the colts (age 9 – 17 months) with 243 432 and 4496 respectively. The Atractidae, Cyathostominae and Spiruridae all presented similar seasonal trends with a small peak in autumn and a large peak in spring. The similarity of these three seasonal trends is unusual since all these nematodes have different life-cycles. Two members of the Strongylinae represented in highest numbers were *Strongylus vulgaris* and *Craterostomum*. The adults of *S. vulgaris* had similar peaks to the other three families, excepting a sharper peak in the spring. The pre-patent period of this strongyle is 5 – 7 months. Infective larvae ingested earlier in the summer could be the reason for the high peak in winter. The seasonal trend of *Craterostomum* was a continual increase from summer to winter and then it decreased. No reason could be given for this phenomenon as the life-cycle is unknown. Further studies of Burchell's zebras will fill the two-month gaps of the present study so that a monthly seasonal picture can be made.

Recent Findings on the Transmission of Anaplasmosis in Cattle

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Biological transmission of *Anaplasma marginale* was demonstrated in the laboratory using the three-host tick, *Rhipicephalus simus*. Transstadial transmission took place from larvae to nymphae, from nymphae to adults and also from larvae to adults, i.e. infection was transmitted from larvae to adults without the nymphae being exposed to a patent parasitaemia.

On three occasions attempts were made to transmit *A. marginale* mechanically with *Stomoxys calcitrans* but only one attempt was successful. All efforts to repeat such a transmission with *Hippobosca rufipes* failed.

Antibodies to a Canine Isolate of *Encephalitozoon* in Various Species

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After the isolation of *Encephalitozoon* in tissue culture from infected dogs, an indirect fluorescent antibody test has been used to determine the prevalence of antibodies to *Encephalitozoon* in various species [Stewart, van Dellen, and Botha (1979). *J. S. Afr. Med. Ass.* 50, 165]. In dogs the prevalence rate was found to be 18% in serum samples submitted for various clinical pathological examinations. In kennels where the infection had been confirmed, 70% of samples gave positive titres. In the rabbit colony of the Veterinary Research Institute, Onderstepoort, serum samples taken at random from 30 breeding does showed a prevalence rate of 40%. No problems due to encephalitozoonosis were encountered at the time of taking the samples. 127 serum samples taken from vervet monkeys from the Kruger National Park showed a prevalence rate of 2%. This probably represents a lack of specificity of the test as no evidence of natural infection was found in these monkeys. *Encephalitozoon cuniculi* has been reported as a zoonosis. However, doubt has been cast on the true nature of these reports [Bywater (1979). *Laboratory Animals* 13, 149]. 742 human serum samples were obtained from clinical pathology laboratories in the Pretoria/Johannesburg area. 2% of these samples had antibodies to the canine isolate of

Encephalitozoon. Eleven of these samples probably represent non-specific reactions as the titres were low; however, 5 had a titre of 1:80, which could be significant. Samples were also collected from five laboratory workers who had worked with the tissue cultures and the owner and family of one of the infected kennels. The owner of the kennel had a positive titre of 1:40. This probably represents exposure to infection without development of clinical symptoms. The remainder of the samples were negative.

This research was supported by a grant from the South African Medical Research Council.

Measurement of Cell-mediated Immunity in Invasive Amoebiasis by the Leucocyte Adherence Inhibition Test

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The majority of workers have employed lymphocyte transformation in response to sensitization with specific amoebic antigen as a means of assessing the presence of cell-mediated immunity in amoebiasis. The leucocyte adherence inhibition test (LAI) relies on the property of leucocytes to cease adhering to clean glass surfaces after incubation with antigens to which they are sensitized. This test has been used with success in tumour immunology and has the advantages that it can be performed relatively rapidly and does not require a radioisotope facility for its performance. This paper describes experience with the establishment of an LAI test for amoebiasis. The findings of a pilot study in which patients with amoebic liver abscess were compared to suitable controls is discussed.

Parasitic Infections in the Population of Northern Kwazulu

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The results were presented of an investigation in which more than 8 000 black subjects living in the Ngwavuma and Umbombo districts of Natal were screened for the presence of urine and stool parasites.

Schistosoma haematobium was extremely common, particularly in the Pongola flood-plain, around Lake Sibaya and in the north-eastern area. The prevalence of *S. mansoni* was very low despite the abundance of its intermediate host, *Biomphalaria pfeifferi*, and active transmission would seem to occur only in the Pongola flood-plain. *S. matthei* infections were rare despite the presence of numerous cattle in the area. Of the stool parasites, *Ascaris lumbricoides*, *Trichuris trichiura* and *Necator americanus* were the most common, particularly in the north-eastern part of the area. The prevalence rates of the other intestinal helminths and all the protozoan species except *Entamoeba coli* (60%) were less than 10%.

Future developments in irrigation and agriculture envisaged for the area are bound to have a profound impact on the parasite load of the population and call for vigilance by health authorities. Large sums of money will be necessary to control parasitic infections in the area but the prevention of soil pollution and water contact involves bypassing long-ingrained human habits which are resistant to change.

On the Ecology of the Avian Schistosome *Austroilharzia terrigalensis* in an Australian Estuary

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Since the early 1960s schistosome dermatitis has become a perennial problem, a recreational disease, amongst users of the Swan estuary, Perth, Western Australia. The causative agent is the avian schistosome *Austroilharzia terrigalensis*, whose adult stage occurs in the mesenteric vein of the Silver Gull *Larus novaehollandiae*. Its intermediate host is the whelk *Velacumantus australis*. This snail is believed to be a recent immigrant to the Swan estuary, having been introduced about 1950. Investigation of *A. terrigalensis* here has established a set of quantitative ecological and epidemiological parameters for various aspects of the parasite's transmission cycle and for the problem of schistosome dermatitis as well. The infective stages of *A. terrigalensis* (egg-output and cercarial emergence) show a close relationship, both temporal and spatial, to the daily water-contact habits of the gulls. Aspects of this cycle for which measurements

were made include prevalence of infection, worm-burden, egg-output and worm longevity in *L. novaehollandiae* and prevalence of the intramolluscan stage in *V. australis*. Transmission of *A. terrigalensis* in the Swan estuary is a seasonal phenomenon. This is a seasonal estuary in which saline water dominates the system throughout the year except for the rainy winter when river discharge flushes the saline water out to sea. When the salinity falls below approximately 20‰, usually in July, *V. australis* becomes inactive and dormant and *A. terrigalensis* cercariae are no longer shed. Its operculum efficiently seals the snail off from the surrounding fresh-water. During the winter the salinity may drop further, to 10‰, for up to three months. Transmission of *A. terrigalensis* cannot resume until spring when the saline water has returned and the salinity risen above approximately 20‰ and water temperature above approximately 20°C. During this period, too, the development of cercariae within the sporocysts is delayed. Walker (1979) showed in Botany Bay, Sydney, that in *V. australis*, *A. terrigalensis* has an obligatory relationship with other trematodes. This was found to be true also for the Swan estuary and a critical prevalence and density of prior-parasitism was determined. The usual partner was the heterophyid *Stictodora lari*. Schistosome dermatitis in the Swan estuary is primarily a disease of children, with the 5 to 9 year age group most frequently at risk. The duration and timing of human contact with the water overlapped with that of the gulls and also with the presence of maximum numbers of cercariae. Lesions generally appeared 12 to 14 hours after exposure and persisted for one to two weeks. If they were scratched open, as often happened when children were involved, they could become secondarily infected and persisted for longer.

Schistosome Transmission Potential of Brackish Waters

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The longevity and infectivity of the cercariae of three schistosome species, *Schistosoma haematobium*, *S. mansoni* and *S. mattheei*, was discussed and related to the field situation.

The longevity of the cercariae of all three species decreased with increasing salinity. The LD₅₀ values decreased from 41–44 hours in salinities of 2.5‰sw – 10‰sw to 10 min in 50‰sw and 3 min in 100‰sw. The infectivity results revealed a distinct decrease in worm burden from salinities of 10‰sw to a less than 5‰ worm return in 25‰sw for all three species. The experimental results indicated that the cercariae can survive and maintain infections in brackish waters as high as 25‰sw in some cases.

Salinities recorded over the past year from stations along the lower 2.5 km of the Amanzimtoti river to the mouth of the lagoon ranged from fresh water to 19‰sw. Thus, considering the experimental results in relation to the range of salinities recorded from the Amanzimtoti, the transmission of schistosomiasis from the intermediate to the definitive host is possible.

Review of the Avian Schistosomes of Africa

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Knowledge of the avian schistosomes (Schistosomatidae) of Africa is scanty. Seventeen species belonging to five genera have been recorded from this continent, but the status of several must be regarded as doubtful. Recent research has revealed the presence of the eggs of three additional species belonging to three genera in faecal samples from indigenous birds in the Durban area. These three are *Trichobilharzia* from Spurwing and Egyptian Geese, *Gigantobilharzia* from Gannets and Black-backed Gulls, and *Austrobilharzia* from Black-backed Gulls. Of these the life-cycle of only the *Trichobilharzia* species is understood, although the adults have not been recovered. Its snail intermediate host is *Lymnaea natalensis*.

Cysticercus cellulosae antigens

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The literature on human infections of *Cysticercus cellulosae* in South Africa was reviewed as was the literature on the antigens of *C. cellulosae* in the context of their use in serological tests.

With the advent of new drugs for the treatment of parasitic cysts, distinction between cysticercosis and hydatidosis becomes increasingly important.

With this in mind a preliminary study of the precipitating antigens of these two parasitic cysts was undertaken. Hydatid cyst fluid and soluble extracts of *C. cellulosae* were precipitated with homologous and heterologous immune sera from patients suffering from these two diseases. The precipitates were dissociated in sodium dodecylsulphate and merceptaethanol and separated by polyacrylamide gel electrophoresis. When precipitated with homologous antiserum, hydatid fluid demonstrated at least five bands, while soluble extracts of *C. cellulosae* exhibited at least 10 peptides. All the peptides had an apparent molecular weight greater than 170 000. When the immunoprecipitates of homologous and heterologous reactions were analysed at least two peptides were found to be specific to the *C. cellulosae* homologous reaction and at least one in the hydatid homologous reaction. These preliminary results suggest that specific antigens can be isolated from *C. cellulosae* and used in a serological test which will not cross-react with cases of hydatidosis.

Cell-mediated Immunity in Amoebiasis

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In vitro tests of cell-mediated immunity (C.M.I.) were done on 23 patients with amoebic liver abscess (A.L.A.), 16 patients with amoebic dysentery (A.D.) and 39 age and sex-matched controls.

T and B cell estimations done by the fluorescing and rosetting technique showed that patients with A.L.A. had a significantly higher number of T cells as compared with the controls ($P \leq 0.0074$). There was no statistical difference in the numbers of T cells in patients with A.D. as compared with their controls. B-cell estimations in patients and controls showed no difference.

Sensitization of lymphocytes was measured by their ability to undergo blast cell transformation in the presence of a universal antigen [phytohaemagglutinin (PHA)] and a specific amoebic antigen. Sensitization to amoebic antigen was more pronounced in patients with A.L.A. as compared to those of A.D. and was significantly higher in both groups as compared with the controls ($P \leq 0.0078$ and $P \leq 0.04$ respectively). A general depression of C.M.I. as measured by a decreased blastogenic response to PHA was observed in patients with A.L.A. ($P \leq 0.001$). There was no difference in inhibition of leucocyte migration in the presence of amoebic antigen in patients and controls.

That C.M.I. occurs in amoebiasis is confirmed. The higher T cell counts and the better response of T cells to stimulation by amoebic antigen in patients with A.L.A. may account for the rarity of recurrence of amoebiasis in this group.

Seasonal Investigation of the Ecto- and Endoparasites of the Barbel, *Clarias gariepinus* (Burchell, 1822), in Lebowa, South Africa

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Clarias gariepinus (Burchell, 1822) of different age-groups and sexes were collected seasonally over a period of two years from eight dams and the Olifants River in Lebowa. They were regularly infested with three trematodes, metacercariae of *Euclinostomum dollfusi* and *Diplostomum mashonense* and adult *Glossidium pedatum*; two cestodes, *Polyonchobothrium clarias* and *Proteocephalus glanduliger*; three nematodes, *Paracramallanus cyathopharynx*, *Procamallanus laevisconchus* and larval *Contraecaecum* spp.; and a crustacean louse, *Dolops ranarum*. With the exception of *Contraecaecum* spp. and *D. ranarum*, these are the first records of the above parasites from Clariidae in South Africa. The prevalence of *G. pedatum* showed seasonal variation with a pronounced peak in spring and a gradual decrease to a minimum in winter.

Immunology of Human Trichomoniasis

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Although trichomoniasis is the most common of the sexually transmitted diseases of man, it has received only scant attention from western parasitologists. Infection stimulates a wide-ranging humoral response involving IgA, IgG, IgM and IgE, though there is no evidence that these antibodies provide protective immunity. Polymorphonuclear leucocytes

(PMN) are attracted to substances secreted by *T. vaginalis*, and the attractant is heat labile and does not pass through dialysis membranes. Human PMN can apparently kill *T. vaginalis* *in vitro*, though in animal studies other cells, for example macrophages, are more cytotoxic.

***Schistosoma mansoni*: Effect of Abnormal Conditions on the Reproductive Status of the Female**

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In *Schistosoma mansoni* the sexually mature female worm produces at least 300 eggs per day. The reproductive system is consequently a highly metabolically active one which has been found to be particularly sensitive to abnormal conditions. In the present paper the *in vivo* responses of the vitelline gland to (a) the effect of drugs, and (b) separation of worm pairs are described.

(a) The drugs Astiban and Hycanthon, when administered at sublethal dose levels to mice with mature infections, had differential effects on particular developmental stages of the vitelline cell [Erasmus and Popiel (1980). *Exp. Parasitol.* 50, 171–187]. Astiban treatment (30 mg kg⁻¹ day⁻¹) resulted in ultrastructural damage to, and elimination of, mature cells and those involved in protein synthesis. After 8 days of treatment only normal undifferentiated cells remained. After drug withdrawal these cells developed normally, and after a 3-day recovery period the original cell population structure of the vitelline gland was restored. Hycanthon treatment (50 mg kg⁻¹ day⁻¹) resulted in the elimination of the early developmental stages of the vitelline cell, and after 10 days of treatment the vitelline gland consisted of a homogeneous population of mature cells only. Because the undifferentiated cells were eliminated from the vitelline gland cell population there was no recovery following drug withdrawal.

(b) Although it is well known that in *S. mansoni* female reproductive development is dependent on the presence of male worms [Armstrong (1965). *J. Parasitol.* 43, 197–206], recent investigations have shown that a male stimulus is also required for the continuous normal functioning of the female reproductive system. This was first suggested by the considerable reproductive regression which took place in residual females observed after elimination of male worms after treatment of host mice with oxamniquine [Popiel and Erasmus (1981). *J. Helminthol.* (in press)]. Further investigations, eliminating the possible involvement of drug action, have been carried out in collaboration with Dr D. Cioli. *S. mansoni* was maintained in Swiss mice from which mature females alone and worm pairs as controls were transferred to recipient Nile rats. In those females transferred alone there was considerable overall size reduction and egg production ceased. The vitelline gland regressed and by day 35 post-transfer the lobules consisted of undifferentiated vitelline cells only. Those females transferred together with male worms showed no such changes.

These observations illustrate the extreme sensitivity of the vitelline gland of *S. mansoni* to adverse conditions and show that the maintenance of normal reproductive status of the female is dependent on continuous stimulation by the male.

Part of this investigation received financial support from the UNDP/World Bank: WHO Special Programme for Research and Training in Tropical Diseases.

Improved Antigen Preparation for the Cercaria Fluorescent Antibody Test

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Cercariae for the cercaria fluorescent antibody test (CFAT) are often supplied freeze-dried and when they are reconstituted the 'heads' and 'tails' often separate. It is accepted that the fluorescence on the surface of the intact cercariae should be considered in assessing the test. Moreover the non-specific background fluorescence can be unacceptably high.

We had previously developed free-floating cercariae preparations, which reduce the problems of cercarial damage and background fluorescence, but to prevent accidental cercarial fracture the cercariae have to be handled carefully, which is both time-consuming and labour-intensive.

We have now developed a preparation in which the cercariae, previously vitally stained with aqueous rhodamine bovine albumin, are fixed in formalin and fixed on the slides with ice-cold acetone [Wolstenholme and Fripp (1981). *Trans. R. Soc. trop. Med. Hyg.* 75, 614–615]. When used for

the CFAT there is a low background fluorescence, and the majority of the cercariae remain intact.

Observations on *Schistosoma intercalatum* in Laboratory Animals

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The strain used in this study was obtained from the original type locality, Yakusu near Kisangani in Zaire, through the courtesy of Dr Martin Taylor, London School of Hygiene and Tropical Medicine. *Mastomys natalensis* and *Saccostomus campestris* were each exposed to 150 cercariae released from *Bulinus (Physopsis) africanus*, in which an infection rate of 54–64% of snails surviving the pre-patent period was obtained. Five other bulinid species, including *B. (B.) forskali*, were refractory. The spindle-shaped eggs tended to be smaller (169 × 5 μm) than either *S. bovis* (ex Iran) (185 × 61 μm) or South African *S. mattheei* (190 μm × 62 μm), and their deposition in the tissues varied in the two hosts (Table 1). Polyacrylamide gel electrophoresis revealed alpha naphthyl acetate esterase isoenzyme patterns which resembled those of *S. haematobium* rather than *S. bovis* or *S. mattheei*.

Table 1. *Schistosoma intercalatum*: distribution of adults and eggs in rodent tissues.

Site	Rodent host	
	<i>Saccostomus</i>	<i>Mastomys</i>
<i>Adult flukes</i>		
Liver	+++	++
Mesenteries	+++	++++
<i>Eggs</i>		
Liver	+++	+++
Lungs	+	+
Small intestines	++	+++
Large intestines	++++	++++
Rectum	++	+++
Spleen	+	+
Bladder	+	++

This study was supported by a grant from the South African Medical Research Council.

Arthropod-borne Disease as a Possible Factor Limiting the Distribution of Birds

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There are about 2 000 kinds of birds inhabiting the Afrotropical zoogeographical region, of which approximately 120 occur in tropical montane evergreen forests at elevations of more than 1525 metres. Despite their potential mobility, only about 39 typically montane forest species are also found in low-lying country, even where the montane forests are separated by only a few kilometres. This phenomenon (also apparent in, for example, tropical South-East Asia and equatorial South America) is difficult to explain.

Warner (Warner (1968). *Condor* 70, 101) found that arthropod-borne disease in the Hawaiian islands (bird malaria and avian pox in particular) limits the distribution of the Drepaniidae to elevations above approximately 600 metres. Field experiments could be conducted in East Africa, to answer the question raised by Rowan of whether the distribution of certain African birds (and other vertebrates) is determined in the same way [Markus (1974). *Int. J. Parasitol.* 4, 609]. This might well be the case if the virus/haematocoon in wild birds which are not immunogenetically resistant is as virulent as in some exotic caged species. The potential exists for continual reintroduction of organisms by Palaearctic and intra-African migrants [Markus, *ibid.*].

Avian *Plasmodium* is known to be a cause of mortality [Beier, Strandberg, Stoskopf and Craft (1981). *J. Wild. Dis.* 17, 247]; but the pathogenicity of protozoa thought not to be harmful for example *Haemoproteus* also needs to be studied, [Julian and Galt (1980). *ibid.* 16, 39], (although the

disease in this case have been sarcocystosis). Effects of organisms on a host species at the periphery of its range, for instance *Leucocytozoon*, require investigation, which I have found in blood from nestling Cape Vultures *Gyps coprotheres* at the declining Potberg colony, Bredasdorp [Boshoff (in press). *Vulture News*] situated at 34°22' S, 20°33' E.

Support from the CSIR is acknowledged.

Admissible Hapantotypical *Sarcocystis* Material

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The designation of meaningful types of *Sarcocystis* and many other protozoa (both free-living and parasitic) is not possible under the current provisions of the International Code of Zoological Nomenclature, which prescribes that a type must consist of a single individual. The *Sarcocystis* problem [Melville (1980). *Z. Parasitenk.* 62, 105. Frenkel, Heydorn, Mehlhorn and Rommel (1980). *Ibid.* 62, 199] led to the formation by the International Commission on Protozoology of a committee to consider, *inter alia*, the matter of choosing types of species with two or more stages in their life-cycle. This amounted to specifying what, in such protozoa, could fulfil the function served by a holotype in most metazoan groups. The concept of a multiple type (hapantotype) was accordingly introduced and is to be incorporated in the forthcoming (3rd) edition of the Code [Melville (1981). *Bull. zool. Nom.* 38, 16].

Of various criteria [Markus (1978). *Adv. vet. Sci. comp. Med.* 22, 159] used for the identification of species of *Sarcocystis*, the fine structure of the cyst wall is the most useful. It is frequently the only convenient means by which two species of *Sarcocystis* can be distinguished. For instance, sarcocysts of *S. cruzi* and the *S. muris* type of organism were used by Garnham *et al.* [Garnham, Bray and Killick-Kendrick (1979). *Bull. zool. Nom.* 36, 17] as examples of muscle cysts which '... are indistinguishable by light microscopy...' At the ultrastructural level, however, these two cyst types are seen to be quite different. They are shown elsewhere, in the same plate [Daly and Markus (1980). *Proc. electron Microscop. Soc. sth. Afr.* 10, 95]. The committee referred to above stated that the orientation of sections for electron microscopy is critical. [Melville (1979). *Bull. zool. Nom.* 35, 200]. In respect of the cyst wall of *Sarcocystis*, the orientation of the section is not particularly critical.

Sarcocystis material for comparative study for the preparation of, for example, isoenzyme prints can be assembled only with difficulty; and comparison with the work of others can only be, at best, indirect. If biochemical and immunological characters are admissible [Melville (1979); (1981) *ibid.*] as hapantotypical *Sarcocystis* material, it is doubtful whether electron micrographs can logically be excluded, as has been recommended. The new provision for hapantotypes will, otherwise, have done little to solve the *Sarcocystis* problem.

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Book Reviews

Evolutionary Ecology. Edited by Bernard Stonehouse and Christopher Perrins. Pp. 310. (Macmillan, London; 1977) Paperback edition, 1979, R14.20.

This book is primarily intended as a tribute to David Lack, one of the giants in the field of ecology, and is not aimed at any particular readership; the 21 papers it contains vary considerably in style and level at which they treat their subjects, some papers being essays while others present unpublished data and yet others are best classified as theoretical research. However, anyone interested in ecology, or biology generally, will find much of the book interesting and stimulating, be he an undergraduate student or researcher. The authors express a refreshing diversity of viewpoints.

The book is divided into four sections, the first three covering themes explored extensively by Lack (population regulation and the function of territory; feeding adaptations and ecological segregation; breeding adaptations and reproductive rates) and the fourth section (behaviour, adaptation and taxonomic relationships) dealing with themes peripheral to Lack's work. To set the title of the book, *Evolutionary Ecology*, in perspective one needs to realize that all the authors here would concur with Hilary Fry's definitions on p. 127 (paraphrased here) that ecology is the study of *why* biological phenomena occur, evolution is the study of the mechanisms by which the phenomena evolved. Nearly all the emphasis in this book is on *why*; how the phenomena came to be is given a back-seat rôle.

I think I can best demonstrate the value of this book, and indicate areas of special interest, by giving brief résumés of some

chapters, not necessarily those that are best.

The first chapter is a somewhat slick but beautifully written account by Wynne-Edwards of the reasons behind his proposing the concept of group selection, an idea which he seems to have rescinded in favour of kin selection. It is extremely thought-provoking even though it may leave the reader unconvinced.

A Tribute to David Lack

The chapter by Adam Watson and that by John Gibb demonstrate what excellent work can be done by people in government organisations. Watson summarizes the extensive studies of population dynamics and territoriality of Red Grouse, carried out mainly by himself and other members of the Institute of Terrestrial Ecology. As yet no clear answer has emerged as to the causes of population fluctuations and overall population limitation but it has been shown that the size of a grouse's territory is related to the amount of food it contains and that possession of a territory is essential for grouse to survive the winter.

Denis Chitty presents a model to explain cyclic fluctuations in numbers of microtine rodents, which is similar in concept to *r* and *K*-selection. He emphasizes the need for true experiments in field studies and points out that the long-standing distinction between density-dependent and density-independent factors in discussions about population regulation is often unnecessary and false.

In his chapter Gibb discusses factors that affect the density of rabbits and points out

parallels between population regulation in rabbits and other small mammals. It is an excellent, clearly written paper in which Gibb shows the naivety of searching for a single, universal factor that controls the size of a population; in fact population size is generally regulated as a result of three associated factors — food, predation and disease — only one of which will *appear* to be limiting in non-experimental field studies.

Bryan Nelson discusses the way in which breeding systems of species are determined by their feeding methods and the food available to them. He uses marine Pelicaniformes to illustrate this thesis and amongst them frigate birds provide a most striking example; their relatively scarce food and specialized feeding methods result in an extraordinarily long breeding cycle. Because it is fed infrequently the chick grows very slowly and then it must be fed for a long time as a free-flying juvenile, until it has mastered its feeding techniques.

Michael Rosenzweig writes about co-existence of heteromyid rodents, and looks at overlap between species in terms of reduction of fitness rather than in the classical way where it is estimated by measuring overlap in use of resources. He derives an ingenious explanation for the narrower range of habitats occupied by the species in sympatry than those in allopatry in spite of the *apparent* absence of competition when classical coefficients of overlap are calculated.

Ian Newton reviews the literature on breeding of tundra-nesting geese. The importance of fat and protein reserves to breeding success is illustrated and Newton points out the value of studies of body con-