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ECTOPARASITIC MITES INFEST COMMON AND WIDESPREAD BUT NOT RARE AND RED-LISTED DRAGONFLY SPECIES

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Freshwater ectoparasitic mites negatively alter host population dynamics by reducing survivorship, mating success, fitness and altering activity patterns. Hosts commonly include dragonflies. The Kogelberg Biosphere Reserve, South Africa, is a major hotspot for endemic dragonflies. All 38 dragonfly species in the reserve were sampled for ectoparasitic mites, but only 2 common, widespread spp. of Zygoptera, *Ischnura senegalensis* and *Ceriagrion glabrum*, were infested with *Arrenurus* or *Leptus* mite spp. None of the endemic or red-listed dragonflies were infested. Parasitism level was 3.5% for *C. glabrum* and 38% for *I. senegalensis*. Intensity of ectoparasites on individuals was high, with about eight ectoparasitic larva per individual. Larval mites preferentially associated with individual hosts already harbouring mites. High levels of species-specific parasitism likely reflects shared environmental requirements, preferential species selection, and lack of defensive behaviours to resist infestation. Characteristic scars from previous mite attachment observed on older individuals of *I. senegalensis* indicate that a much larger percentage of the population was actually parasitized, but detached as the individual aged. That the rare and red-listed species were apparently immune from infestation is a positive note for their conservation.

INTRODUCTION

Aquatic insects host many parasite taxa (ROLFF, 2000). Ectoparasitic mites are a common and widespread parasite in freshwater, and are associated with nearly all aquatic insects (SMITH & OLIVER, 1986), and are frequently in densities exceeding 200 per square metre (SMITH, 1988). The most conspicuous and prevalent aquatic ectoparasitic mites affecting Odonata are the Hydrachnidia (=

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Hydrachnellae, = Hydracarina), or water mites (SMITH, 1988). Among the hydrachnids, Arrenuridae is the main family parasitic on Odonata (CORBET, 1999). In addition, the terrestrial mites, Erythraeidae (Acari, Parasitengona), have been recorded as ectoparasites of adult Odonata (TURK, 1945). Their larvae actively seek out and crawl to adult Odonata within range. The Arrenuridae life cycle usually involves both a free-living and a parasitic stage (SMITH, 1988). The egg, laid underwater, hatches and releases a hexapod larva which swims freely. This larva then seeks out a final instar host larva and attaches phoretically (ROLFF & MARTENS, 1997). During emergence, the mite larvae utilize a vulnerable stage during which it transfers to the teneral odonate and stays attached as an ectoparasite, feeding on the host's body fluids (ROLFF et al., 2001). Eventually the hexapod larva drops away from the host into water and moults into the first resting stage, the nymphochrysalis. An additional moult soon after, releases the octopod larva, which is an active subaquatic predator of microcrustacea. After a second resting stage, the teliochrysalis, it is followed by another moult, and the reproductive adult emerges and the life cycle continues (CORBET, 1999).

Ectoparasites are known to alter population dynamics by reducing host fitness, decreasing mating success, negatively impacting survivorship, and by changing the host's activity patterns (FORBES & BAKER, 1991; LEHMANN, 1993; BAKER & SMITH, 1997; ANDRES & CORDERO, 1998; LEONARD et al., 1999; ROLFF et al., 2000; ROLFF, 2000, 2001; LEUNG et al., 2001; BRAUNE & ROLFF, 2001; BOTMAN et al., 2002; CONRAD et al., 2002). Due to the potential impact that ectoparasites pose to Odonata, the aim of this study was to determine the level of the ectoparasite burden on Odonata within the Kogelberg Biosphere Reserve (KBR), a major reserve for these odonates, and many other taxa, in a global biodiversity hotspot (Cape Floristic Region). Patterns of site attachment in individual Odonata were also investigated to determine whether mites directly interfere with spiracles, legs, wings or particular organs.

SITE AND METHODS

Site. – The Kogelberg Biosphere Reserve has a rich flora (COWLING, 1992; BOUCHER, 1978) and rich Odonata fauna (GRANT & SAMWAYS, 2007). It is in the Western Cape, South Africa, 30 km E of Cape Point across False Bay. It stretches inland from the southeastern limit of False Bay, to the Bot River and North to Grabouw and the Groenlandberg Mountains (34°04'-34°24'S; 18°48'-19°12'E). This area is a Mediterranean climate (BOUCHER, 1978) with cool wet winters and hot, dry summers which are tempered by cool cloud and mists off the ocean. Throughout the area, variation in rainfall is considerable, with a strong orographic component that varies with topography (BOUCHER, 1982; JACKELMAN et al., 1999).

Methods. – Sampling of adult Odonata occurred in the KBR during August 2003 to August 2004, during various times between 09h00 and 17h00 and was restricted to warm, sunny, windless days when Odonata are generally the most active (CORBET, 1999). BROOKS (1993) suggests that monitoring of Odonata populations should only be done during weather conditions best suited for their activity. Therefore, cooler, windy, overcast days when species are less abundant were avoided.

1149 sample sites, consisting of 3×3 m quadrats, were chosen arbitrarily throughout the study area in as many different habitats as possible to encompass a wide range of Odonata species, as they are well-known to have diverse biotope preferences. Adult males were recorded visually by use of 10×25 Pentax binoculars during 15 min observation periods, either perched or on the wing. Where identification was uncertain, specimens where caught, identified by a 16× hand lens and released.

Within randomly selected quadrats, a catch-and-release method was employed for all individuals encountered. Individuals observed to have ectoparasitic mite larvae were recorded along with the number and position of larvae. Parasitized individuals, to a maximum of five per species, as allowed under the CapeNature permit, were collected and preserved in 75% ethanol for later identification.

RESULTS

A total of 38 Odonata species and a total of 5381 individuals were recorded in the KBR, of which 601 individuals or 11.2% were inspected for ectoparasitic mites (Fig. 1). Prevalence of parasitized hosts was 4.9% of the sampled population, or 30 individuals. These individuals were from only two species of Zygo-

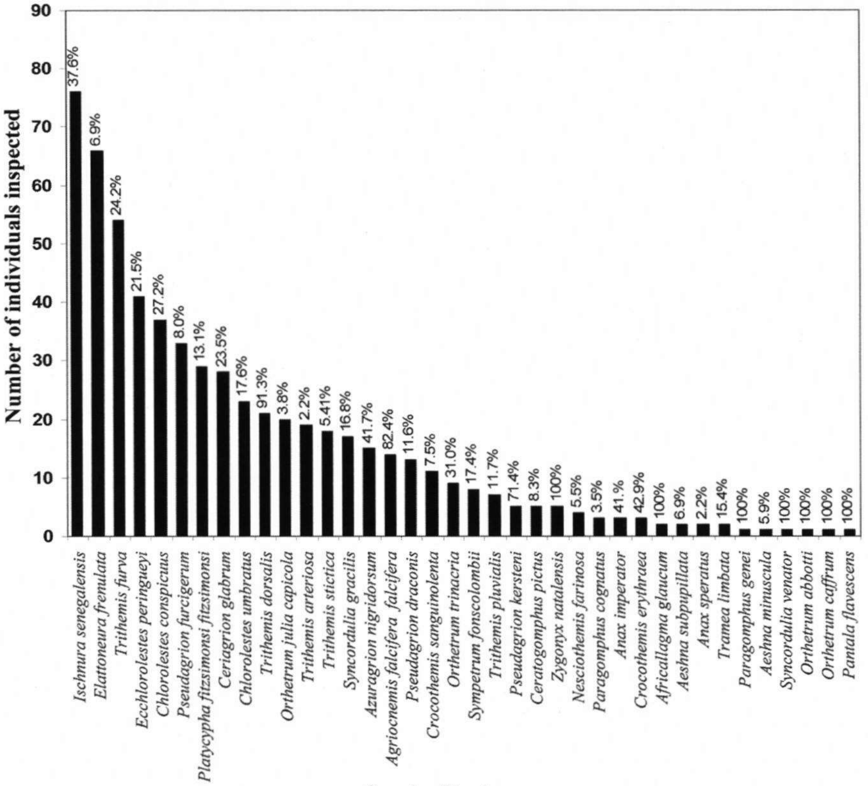

Fig. 1. Rank abundance of individuals sampled for ectoparasitic mites with percentage of sampled individuals out of the total observed population.

ptera, *Ceriagrion glabrum* (Burm.) and *Ischnura senegalensis* (Ramb.). Within these two species, the parasitism level, or the total number of parasitized hosts divided by the total number of potential hosts, was 3.5% for *C. glabrum*, which was only a single parasitized individual, and 38% for *I. senegalensis*, which was 29 parasitized individuals. The intensity of ectoparasites on individuals was approximately eight ectoparasites per individual (Fig. 2). Attachment of all ectoparasites was observed to be restricted solely to the thoracic sutures, generally in a clumped distribution. No direct interference with spiracles, legs, wings or particular organs was evident. *I. senegalensis* individuals were observed with characteristic scars from previous mite attachment, however no attached mites were observed in conjunction with these scars.

Two genera of larval ectoparisitic mites from two separate families were identified and found together on individual Odonata. *Arrenurus*, family Arrenuridae, was the dominant ectoparasite, and *Leptus*, in the family Erythraeidae.

DISCUSSION

ECTOPARASITIC MITE BEHAVIOUR

Almost all species of water mites that are parasitic as larvae use insects as hosts. No consistent patterns seem to exist between density of potential hosts and parasitism by larval mites (SMITH, 1988), and GLEDHILL et al. (1982) suggest that such density dependence does not exist. Upon hatching, larval mites can locate and take advantage of potential hosts over short distances, by actively searching or accidental contact, by responding to water currents, shadows or chemical cues (LANCIANI, 1971; SMITH, 1988). Typically, species of larval water mites are associated with a range of host species, although often specific host species are more heavily parasitized than others (BOOTH & LEARNER, 1978; KOUWETS

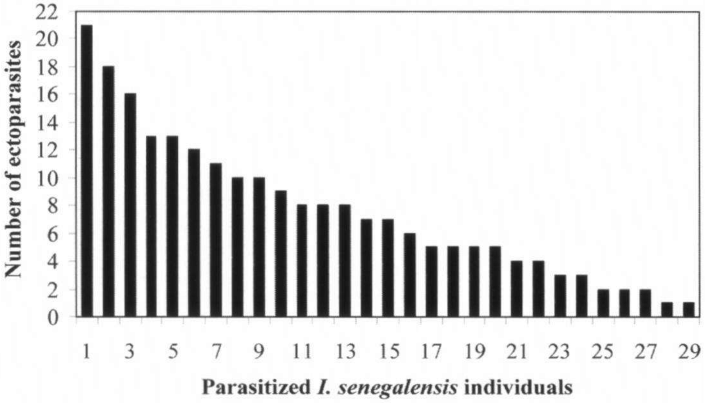

Fig. 2. Mean intensity of ectoparasites on *Ischnura senegalensis*.

& DAVIDS, 1984). When species specificity does exist, it likely reflects similar environmental requirements between parasite and host. As larval mites generally do not respond to insects outside of their normal host spectrum, primary hosts are either preferred or more susceptible to parasitism (SMITH & McIVER, 1984).

ECTOPARASITIC MITE LOADS

Differences in the extent of infestation among host species can also be related to host morphology (GLEDHILL et al., 1982) and defensive response (SMITH & McIVER, 1984). Furthermore, certain species will consistently bear the highest abundance and prevalence of mites irrespective of the hosts' relative size or abundance (BOOTH & LEARNER, 1978). CORBET (1999) mentions that Zygoptera appear to be parasitized more often than Anisoptera. Certainly here, *I. senegalensis* is a preferred host. Interestingly, *C. glabrum* occurs in the same habitat (marshy areas) suggesting that this may also be a preferred habitat for the mites as well. *I. senegalensis* may not be able to resist infestation through defensive behaviours. Furthermore, defensive behaviours in Odonata, including grooming, are reduced in the presence of fish predators, which increases the risk of parasitism (BAKER & SMITH, 1997). The impact of voracious predatory invasive alien fish in the Palmiet River within the KBR could therefore potentially play a role in increased mite burdens in Odonata species.

Not all host individuals of Odonata have an equal likelihood of parasitism within a specific species (SMITH, 1988). While nutritionally stressed individuals may not be able to maintain effective defensive behaviours against infestation, increasing their risk of being parasitized (LEUNG et al., 2001). Ectoparasitic larval mites also associate with individual hosts already harbouring mites (SMITH, 1988). In nature, the parasitism of aquatic insects by larval mites often exceeds 20% (MITCHELL, 1968; AIKEN, 1985; SMITH, 1988). Mite loads can vary between years and populations, resulting in occasional 100% parasitism rates of some species (CORBET, 1999; ROLFF, 2000). Intensities of 50 or more ectoparasitic larvae are also common on some species of Odonata (MITCHELL, 1967). In *Ischnura elegans* (Vander L.), mite loads of 150 mites per adult have even been recorded (CORBET, 1999). Aggregations on specific individuals of a species also occurs (BOOTH & LEARNER, 1978; AIKEN, 1985; SMITH, 1988) and is a typical trait among parasites in general (ANDERSON, 1978).

Most larvae have characteristic locations of attachment, depending on the species of mite, and this varies with the species of host (SMITH, 1988). However, MITCHELL (1967) states that for some *Arrenurus* species which are parasitic on dragonflies, the site of attachment is determined by timing rather than site recognition. These parasites attach to the first segment they contact. Ectoparasitic mites in Erythraeidae tend to attach to most parts of the host, except for the wings. In addition to other detrimental effects, mites attached to the thorax of

Odonata can damage flight muscles, thereby reducing flight capacity (CORBET, 1999). Individual hosts bearing larvae of more than one species are also relatively common (SMITH, 1988).

After engorgement has been completed, mites detach from their hosts in response to various cues, to complete their life cycle. Detachment typically occurs while the host is in a habitat where both host and parasite can best develop and reproduce (ROLFF & MARTENS, 1997). Although some mite species attach after sexual maturation, dragonflies generally lose 75% of their mite load after commencing sexual activity. Brownish scars, often associated with previous sites of attachment, were observed frequently on *I. senegalensis* individuals, indicating that a larger percentage of the population may be parasitized over time.

SIGNIFICANCE FOR CONSERVATION

These findings tend indicate that *I. senegalensis* is the only heavily parasitized species within the KBR. The Odonata fauna of the KBR is unique as it is a stronghold for many highly endemic and red-listed species, which were not parasitized. *I. senegalensis*, unlike many of the zygopterans present in the reserve, is a successful, widespread species, which may have implications for its high rate of parasitism. Similarly, so is *C. glabrum*, a widespread and common species. These patterns support PRICE et al. (1988) who state that species with larger geographic ranges carry more parasitic species as they have a greater probability of aquiring new parasitic species over areas of their geographic range, which become incorporated into that species general parasitic species pool. Indeed, other studies have also shown that common, widespread species including birds (GREGORY, 1990), and bumblebees (DURR & SCHMID-HEMPEL, 1995) have higher parasite loads than hosts with a local distribution. Furthermore, as ectoparasitic mites often show host specificity and similar environmental requirements to the host, may explain why rare and red-listed species in the KBR do not have the added pressure of detrimental ectoparasite burdens. As little is still known about ectoparasitic associations with Odonata or other insect taxa, highlights the importance of investigations of this nature in this and other areas of the globe.

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REFERENCES

AIKEN, R.B., 1985. Attachment sites, phenology, and growth of larvae of Eylais sp. (Acari) on Dytiscus alaskanus J. Balfour-Browne (Coleoptera: Dytiscidae). *Can. J. Zool.* 63: 267-271.

ANDERSON, R.M., 1978. The regulation of host population growth by parasitic species. *Parasitology* 76: 119-157.

ANDRES, J.A. & A. CORDERO, 1998. Effects of water mites on the damselfly Ceriagrion tenellum. *Ecol. Ent.* 23: 103-109.

BAKER, R.L. & B.P. SMITH, 1997. Conflict between antipredator and antiparasite behaviour in larval damselflies. *Oecologia* 109: 622-628.

BOOTH, J.P. & M.A. LEARNER, 1978. The parasitization of chironomid midges (Diptera) by water mite larvae (Hydracarina: Acari) in a eutrophic reservoir in South Wales. *Arch. Hydrobiol.* 84: 1-28.

BOTMAN, G., L. COENEN & C.A. LANCIANI, 2002. Parasitism of Ischnura posita (Odonata : Coenagrionidae) in Florida by two species of water mites. *Fla Ent.* 85: 279-280.

BOUCHER, C., 1978. Cape Hangklip area, 2. The vegetation. *Bothalia* 12: 455-497.

BOUCHER, C., 1982. The Kogelberg state forest and environs, a paradise for Cape flora. *Veld & Flora* 68: 9-11.

BRAUNE, P. & J. ROLFF, 2001. Parasitism and survival in a damselfly: does host sex matter? *Proc. R. Soc. London* (B) 268: 1133-1137.

BROOKS, S.J., 1993. Review of a method to monitor adult dragonfly populations. *J. Br. Dragonfly Soc.* 9: 1-4.

CONRAD, K.F., K.H. WILLSON, K. WHITFIELD, I.F HARVEY, C.J. THOMAS & T.N. SHERRATT, 2002. Characteristics of dispersing Ischnura elegans and Coenagrion puella (Odonata): age, sex, size, morph and ectoparasitism. *Ecography* 25: 439-445.

CORBET, P.S., 1999. *Dragonflies: behavior and ecology of Odonata.* Cornell Univ. Press, New York.

COWLING, R.M., 1992. *The ecology of Fynbos: nutrients, fire and diversity.* Oxford Univ. Press, Cape Town.

DURR, S. & P. SCHIMD-HEMPEL, 1995. Parasites and the regional distribution of bumblebees. *Ecography* 18: 114-122.

FORBES, M.R.L. & R.L. BAKER, 1991. Condition and fecundity of the damselfly, Enallagma ebrium (Hagen): the importance of ectoparasites. *Oecologia* 86: 335-341.

GLEDHILL, T., J. COWLEY & R. GUNN, 1982. Some aspects of the host : parasite relationships between adult blackflies (Diptera: Simuliidae) and larvae of the water-mite, Sperchon setiger (Acari; Hydrachnellae) in a small chalk stream in souther England. *Freshw. Biol.* 12: 345-357.

GRANT, P.B.C. & M.J. SAMWAYS, 2007. Montane refugia for endemic and red listed dragonflies in the Cape Floristic Region biodiversity hotspot. *Biodiv. Conserv.* [in press].

GREGORY, R.D., 1990. Parasites and host geographic range as illustrated by water fowl. *Funct. Ecol.* 4: 645-654.

JACKELMAN, J., P. LINDER, M. PICKER & A. VON HASE, 1999. *Nomination proposal for the Cape Floristic Region. Phase 1: Cape Peninsula protected natural environment to be listed as a World Heritage Site.* Prepared by South African National Parks in collaboration with Western Cape Nature Conservation; funded by World Wide Fund for Nature, Department of Environmental Affairs and Tourism, Republic of South Africa.

KOUWETS, F.A.C. & C. DAVIDS, 1984. The occurrence of chironomid imagines in an area near Utrecht (the Netherlands), and their relations to water mite larvae. *Arch. Hydrobiol.* 99: 296-317.

LANCIANI, C.A., 1971. Host exploitation and synchronous development in a water mite parasite of the marsh treader Hydrometra myrae (Hemiptera: Hydrometridae). *Annls ent. Soc. Am.* 64: 1254-1259.

LEHMANN, T., 1993. Ectoparasites, direct impact on host fitness. *Parasitology Today* 9: 8-13.

LEONARD, N.J., M.R. FORBES & R.L. BAKER, 1999. Effects of a mite, Limnochares americana

(Hydrachnida : Limnocharidae), on the life-history traits and grooming behaviour of its damselfly host, Enallagma ebrium (Odonata: Coenagrionidae). *Can. J. Zool.* 77: 1615-1622.

LEUNG, B., M.R. FORBES & R.L. BAKER, 2001. Nutritional stress and behavioural immunity of damselflies. *Anim. Behav.* 61: 1093-1099.

McGEOCH, M.A. & M.J. SAMWAYS, 1991. Dragonflies and the thermal landscape: Implications for their conservation (Anisoptera). *Odonatologica* 20: 303-320.

MITCHELL, R.D., 1967. Host exploitation of two closely related water mites. *Evolution* 21: 59-75.

MITCHELL, R.D., 1968. Site selection by larval water mites parasitic on the damselfly Cercion hieroglyphicum Brauer. *Ecology* 49: 40-47.

PRICE, P.W., M. WESTOBY & B. RICE, 1988. Parasite-mediated competition: some predictions and tests. *Am. Naturalist* 131: 544-555

ROLFF, J., 2000. Water mite parasitism in damselflies during emergence: two hosts, one pattern. *Ecography* 23: 273-282.

ROLFF, J., 2001. Invited review: Evolutionary ecology of water mite-insect interactions, a critical appraisal. *Arch. Hydrobiol.* 152: 353-368.

ROLFF, J., H. ANTVOGEL & I. SCHRIMPF, 2000. No correlation between ectoparasitism and male mating success in a damselfly: why parasite behavior matters. *J. Insect Behav.* 13: 563-571.

ROLFF, J. & A. MARTENS, 1997. Completing the life cycle: detachment of an aquatic parasite (Arrenurus cuspidator, Hydrachnellae) from an aerial host (Coenagrion puella, Odonata). *Can. J. Zool.* 75: 655-659.

ROLFF, J., C. VOGEL & H.J. POETHKE, 2001. Co-evolution between ectoparasites and their insect hosts: a simulation study of a damselfly-water mite interaction. *Ecol. Ent.* 26: 638-645.

SMITH, B.P., 1988. Host-parasite interaction and impact of larval water mites on insects. *Annu. Rev. Ent.* 33: 487-507.

SMITH, B.P. & S. McIVER, 1984. Factors influencing host selection and successful parasitism of Aedes spp. mosquitoes by Arrenurus spp. mites. *Can. J. Zool.* 62: 1114-1120.

SMITH, I.M. & D.R. OLIVER, 1986. Review of parasitic associations of water mites (Acari: Parasitengona; Hydrachnida) with insect hosts. *Can. Ent.* 118: 407-472.

TURK, F.A., 1945. Studies of Acari. Second series: description of new species and notes on established forms of parasitic mites. *Parasitology* 36: 133-141.