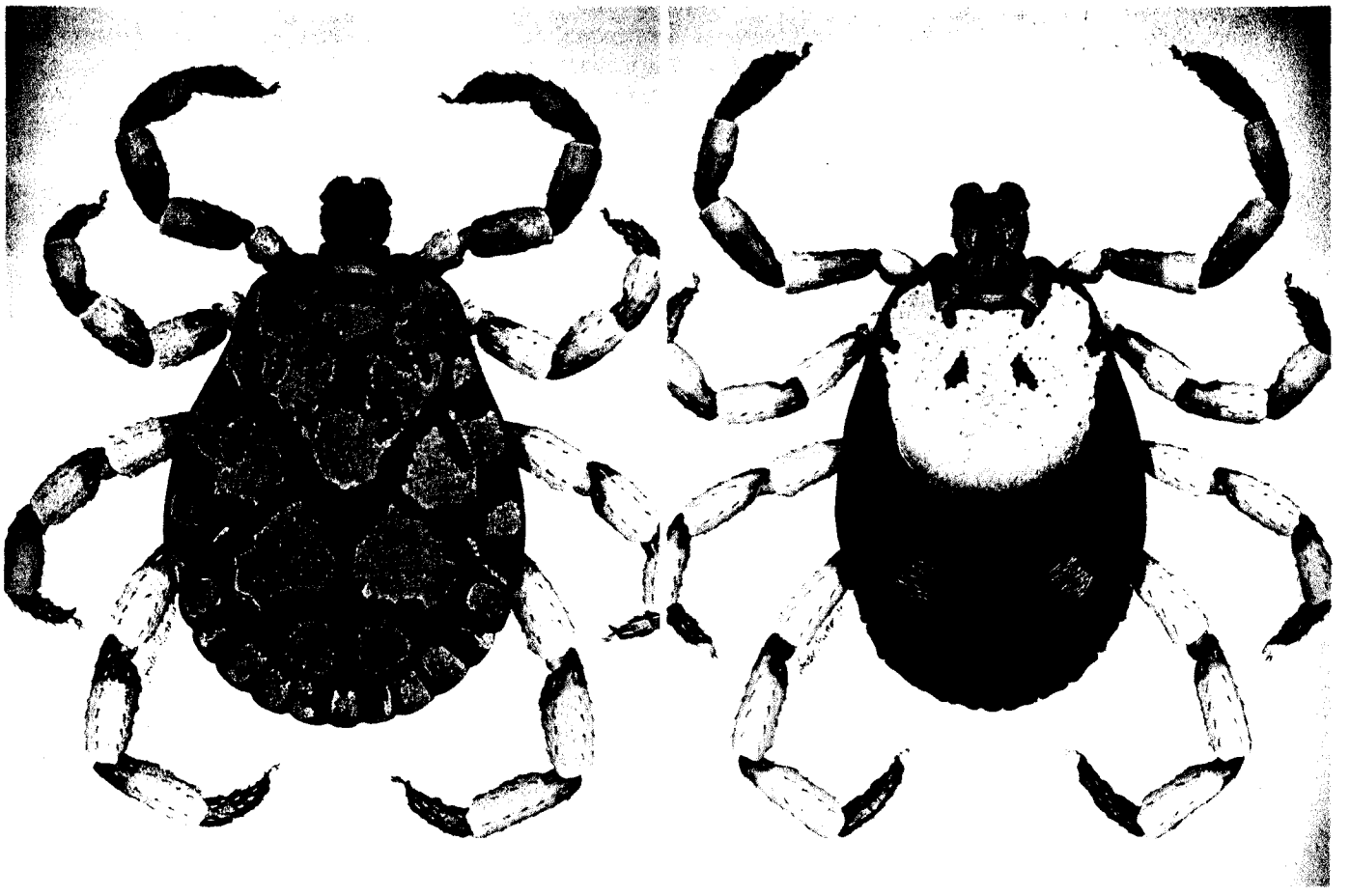


D. rhinocerinus—dorsal view of male (left) and unfed female (Illustrations by A. Olwage, Courtesy of Onderstepoort Journal of Veterinary Research, South Africa), a parasite of African rhinoceroses (male and female body lengths, 8 mm).

Host–Parasite Coextinction and the Plight of Tick Conservation

LANCE A. DURDEN AND JAMES E. KEIRANS

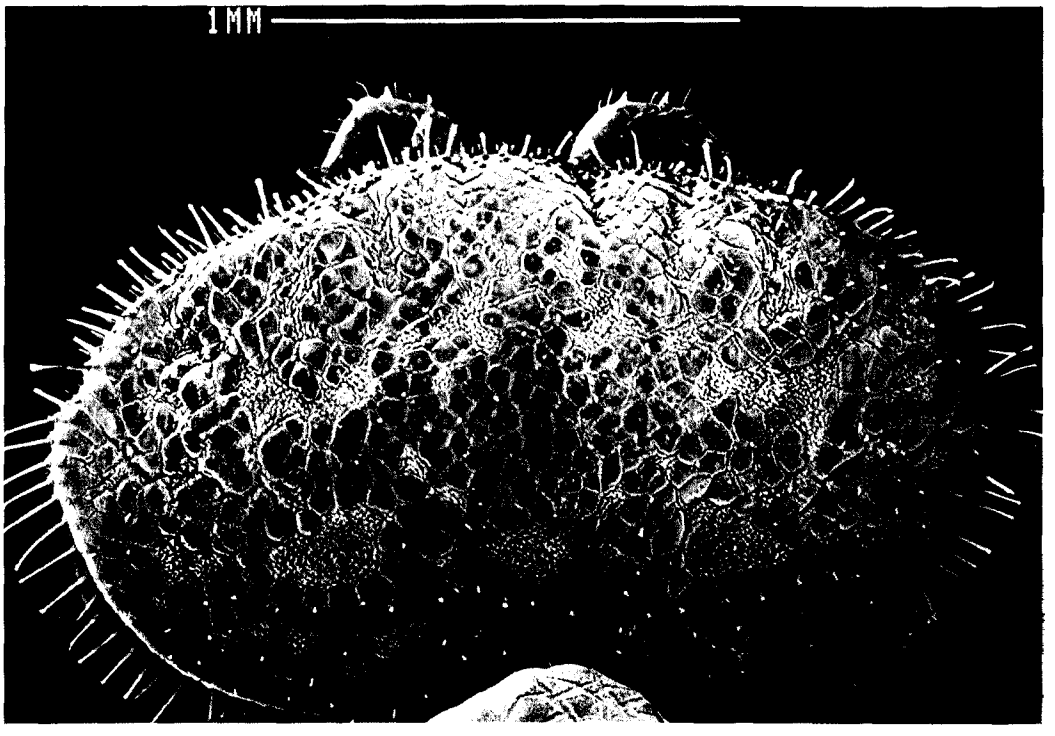
THE DILEMMA OF PRESERVING THE PARASITE biodiversity of rare, endangered, or extinct hosts has been highlighted recently (Windsor 1990, 1995; Rózsa 1992; Stork & Lyal 1993). Host extinction also results in coextinction in nature of all associated host-specific parasites. Further, visible ectoparasites often are removed purposely from rare or endangered animals with an aim towards increasing host fitness and survival. Because the number of parasitic species may be about four times that of free-living species on earth (May 1992), such practices could have dire consequences for parasite biodiversity, which represents a significant proportion of total biodiversity. Negative human perception of parasites, in addition to the typically small size of the latter, has hindered the conservation of rare parasites and actually has decreased the abundance of certain species.

Few, if any, parasites rank lower on the human acceptance scale than ticks. Although many ticks feed on a broad spectrum of host animals, a significant proportion of the approximately 850 extant tick species (Keirans 1992) is host specific, especially in the adult stage (Hoogstraal & Aeschlimann 1982). For example, adults of *Amblyomma tuberculatum* Marx, the largest tick native to North America, feed exclusively on the gopher tortoise, *Gopherus polyphemus* (Daudin). The latter is a threatened reptile of coastal plain sandhill habitats with a diminishing patchy geographical distribution extending from

South Carolina to Louisiana (Hoogstraal & Aeschlimann 1982). Because of urbanization and human encroachment, attempts to relocate colonies of these tortoises are frequent, with intentional tick removal being a common practice before tortoises are released into a new site. Additional similar situations exist where ticks or other parasites are removed deliberately from rare hosts with the premise of alleviating stress exerted by parasites on the hosts.

A more drastic situation involves parasites, including ticks, that feed on African rhinoceroses. Four tick species, *Amblyomma personatum* Neumann, *A. rhinocerotis* (De Geer), *Dermacentor rhinocerinus* (Denny), and *Cosmiomma hippopotamensis* (Denny), as well as numerous other parasites, feed exclusively, or almost so, on white, *Ceratotherium simum* (Burchell), and/or black, *Diceros bicornis* (L.) rhinoceroses (Hoogstraal & Aeschlimann 1982, Walker 1991, Keirans 1993, Penzhorn et al. 1994). The recent drastic reduction in African rhinoceros populations is well documented (Walker 1994). Not surprisingly, a parallel plunge in populations of the four above-mentioned tick species appears to have accompanied that of the rhinoceroses. In fact, it has been suggested that *A. personatum* could soon become extinct (Penzhorn et al. 1994). Again, the situation is exacerbated by the purposeful removal of ticks from captured rhinoceroses before they are released (Duncan 1989). This practice has been followed partly because *Amblyomma sparsum* Neumann, a tick that feeds on several ungulates, including rhinoceroses, is a proven vector of *Cowdria ruminantium* (Cowdry), the causative agent of heartwater disease in ungulates (Walker 1987, Duncan 1989). As an apparent corollary, a documented decline in populations of oxpeckers, *Buphagus* spp., which feed largely on ticks parasitic on rhinoceroses and other large mammals in southern Africa, may be a consequence of the current scarcity of these ticks as well as the application of acaricides (Bezuidenhout & Stutterheim 1980).

The common practice of intentional parasite removal, either directly or by the administration of parasiticides, often seems justified if the survival of a host species is at stake. This impinges on the frequently posed question, "Of what use are ticks?" Given their blood-feeding habit and the numerous pathogens they transmit, most people would instinctively answer "none." However, ticks (and other parasites) are an integral component of healthy ecosystems and have important roles in nature, some of which may still be incompletely understood. It is known that parasites exert selective pressure on host populations and are at least partially responsible for maintaining higher levels of genetic diversity in their hosts when compared to nonparasitized animals (Dawkins 1990, Rózsa 1992, Klein & Ohuigin 1994, Lively & Howard 1994). Further, the very acts of parasitism or pathogen transmission by ticks help to eliminate



O. transversus—dorsal view (scanning electron micrograph) of male—a morphologically and biologically unique tick parasite of Galapagos giant tortoises.

Table 1. Candidate ticks for endangered status

Tick species	Host(s)	Geographical distribution
	Argasidae	
Argas echinops Hoogstraal, Uilenberg & Blanc	Tenrecs	Madagascar
Nothoaspis reddelli Keirans & Clifford	Bats	Mexico
Ornithodoros galapagensis Kohls, Clifford & Hoogstraal	Iguanas	Galapagos Islands
Ornithodoros transversus (Banks)	Giant tortoise	Galapagos Islands
	Nuttalliellidae	
Nuttalliella namaqua Bedford	Unknown	Southern Africa
	Ixodidae	
Amblyomma babirussae Schulze	Babyrussa, etc.	Sulawesi, Indonesia
Amblyomma boulengeri Hirst & Hirst	Iguanas	Galapagos Islands
Amblyomma chabaudi Rageau	Tortoises	Madagascar
Amblyomma crenatum Neumann	Rhinoceroses	Southern Asia
Amblyomma echidnae Roberts	Echidna	Australia
Amblyomma macfarlandi Keirans, Hoogstraal & Clifford	Giant tortoise	Galapagos Islands
Amblyomma personatum Neumann	Rhinocersoses	Africa
Amblyomma pilosum Neumann	Giant tortoise	Galapagos Islands
Amblyomma rhinocerotis (De Geer)	Rhinoceroses	Africa
Amblyomma robinsoni Warburton	Komodo dragon	Komodo island group, Indonesia
Amblyomma squamosum Kohls	Water monitor	Guam
Amblyomma usingeri Keirans, Hoogstraal & Clifford	Iguanas	Galapagos Islands
Amblyomma williamsi Banks	Iguanas	Galapagos Islands
Anomalohimalaya cricetuli Teng & Huang.	Small mammals	Himalayan region
Anomalohimalaya lama Hoogstraal, Kaiser & Mitchell	Small mammals	Himalayan region
Anomalohimalaya lotozkyi Filippova & Panova	Small mammals	Himalayan region
Aponomma komodoense Oudemans	Komodo dragon	Komodo island group, Indonesia
Aponomma sphenodonti Dumbleton	Tuatara	New Zealand
Cosmiomma hippopotamensis (Denny)	Rhinoceroses	Southern Africa
Dermacentor rhinocerinus (Denny)	Rhinoceroses	Southern Africa
Haemaphysalis caucasica Olenev	Hares	Iran, southwestern Russia
Haemaphysalis kadarsani Hoogstraal & Wassef	Shrew rats	Sulawesi, Indonesia
Haemaphysalis lemuris Hoogstraal	Lemurs	Madagascar
Haemaphysalis palawanensis Kohls	Carnivores	Palawan, Philippines
Haemaphysalis simplicima Hoogstraal & Wassef	Tenrecs	Madagascar
Haemaphysalis subelongata Hoogstraal	Tenrecs	Madagascar
Haemaphysalis theilerae Hoogstraal	Tenrecs	Madagascar
Haemaphysalis tiptoni Hoogstraal	Tenrecs	Madagascar
Ixodes dawesi Arthur	Otter shrew	Central Africa
Ixodes galapagoensis Clifford & Hoogstraal	Rice rat	Galapagos Islands
Ixodes hyatti Clifford, Hoogstraal & Kohls	Pikas	Himalayan region
Ixodes lemuris Arthur	Lemurs	Madagascar
Ixodes lunatus Neumann	Tenrecs	Madagascar
Ixodes okapiae Arthur	Okapi	Central Africa
Ixodes ornithorhynchi Lucas	Platypus	Australia
Ixodes peromysci Augustson	Deer mouse	Insular California, USA
Ixodes pomerantzi Kohls	Rabbits	Neotropics
Ixodes shahi Clifford, Hoogstraal & Kohls	Pikas	Himalayan region
Ixodes vestitus Neumann	Marsupial anteater	Australia
Ixodes zaglossi Kohls	Echidna	New Guinea
Margaropus reidi Hoogstraal	Giraffe	Africa
Margaropus wileyi Walker & Laurence	Giraffe	Africa
Rhipicephalus deltoideus Neumann	Unknown	Swaziland

We have principally included tick species with restricted host or geographical distributions, or both, especially those of large vertebrates with potentially vulnerable populations. Several infrequently collected tick species known to parasitize small vertebrates are excluded from this list because few or no data are available concerning their abundance in nature.

weak or susceptible host individuals in nature, thereby maintaining a healthier host population (Potts et al. 1994). For example, in the southeastern United States, large populations of the lone star tick, *Amblyomma americanum* (L.), can kill susceptible white-tailed deer, *Odocoi- leus virginianus* (Zimmermann) (Bolte et al. 1970).

Ticks also are proving to be storehouses of useful biochemicals. Medicinal uses of purified tick anticoagulants have been demonstrated recently (Waxman et al. 1990, Karczewski et al. 1994). In fact, a plethora of pharmaceutically active compounds are currently being isolated from ticks, thereby providing an incentive for drug companies and researchers to initiate further investigations. For example, tick saliva includes components with antiplatelet, apyrase, antihemostatic, antiinflammatory, immunosuppressive, and bacteriocidal properties (Ribeiro et al. 1985, 1991; Ramachandra & Wikel 1992; Keller et al. 1993; Kubes et al. 1994; Alekseev et al. 1995). One salivary tick component, calreticulin, decreases thrombosis in canine coronary arteries and stimulates nitric oxide biosynthesis (Jaworski et al. 1995, Kuwabara et al. 1995). These and related tick-derived compounds currently under investigation suggest that beneficial uses of such products in veterinary and health care fields are on the horizon.

On the lighter side, ticks or analogies of them have entertained some of us by starring in feature films such as *Ticks* and in the cartoon *The Tick*. Moreover, the colors and patterns of some ticks are aesthetically pleasing; these are unusual and incompletely understood traits for ectoparasites.

It may shock some people to learn that, because of the increasing scarcity of certain African ticks, an International Society for the Preservation of Tick Species with the slogan "Save the Ticks" convened at a conference in Kruger National Park, South Africa, in 1991. Given the preceeding paragraphs, this concept is not as absurd as it seems initially. As with most parasites, tick conservation is best practiced through host conservation and by avoiding widespread use of parasiticides. Some ecosystems may be little affected by the loss of one or two parasite species, but the loss of more species could have drastic consequences. For example, if rhinoceros ticks become extinct in southern Africa, populations of oxpeckers and other tick-feeding birds may plummet, which could detrimentally affect the environment in other ways. To promote the idea of conserving rare ticks, we have prepared a working list of world ticks that may be endangered. Almost all of the ticks listed are parasites of only one or a few rare, endangered, or geographically restricted vertebrate hosts. The unique ticks that parasitize the large reptiles endemic to the Galapagos Islands are a prime example of candidate ticks to be conserved. The morphologically and biologically unique *Ornithodoros transversus* (Banks), which feeds exclusively on Galapagos giant tortoises, is one such tick. Because the fauna of the Galapagos Islands is already relatively well protected and monitored, conserving these ticks should not pose a major problem. However, it may be difficult to promote tick conservation to people and governments in developing nations where greater immediate priorities exist and where other common tick species may be significant pests of livestock or humans. Even on the Galapagos Islands, recent revolts by fishermen have threatened some conservation efforts there.

Our intention in this paper has been to provoke interest in the plight of rare ticks and other parasites and to propose that conservation measures be considered. If we are concerned with the conservation of all biodiversity, perhaps the practice of parasite removal from rare hosts should be reevaluated. Although fewer parasite species would come as a welcome relief to most animals, including humans, such a loss also would result in significantly less biodiversity, less development of pharmacologically useful compounds, genetically compromised host populations, and damaged ecosystems.

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