Exotic arthropods in the Kruger National Park, South Africa: modes of entry and population status

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At least 21 species of exotic arthropods have successfully established breeding populations in the Kruger National Park, South Africa. Of these, seven species were intentionally introduced as biological control agents of alien weeds, four species inadvertently accompanied vertebrate hosts during game translocation, and the remainder are presumed to have gained entry through packing crates, human activities, or natural dispersal in some instances. The modes of entry of exotic species are discussed and, where known, the time of first appearance in the Kruger National Park recorded. The rapidly escalating practice of wildlife translocation within and between countries is discussed in relation to passive transfer of diseases and parasites, and reasons are listed why routine precautionary steps should be instituted to avoid transfer of non-target organisms during translocation operations.

Keywords: alien species, wildlife translocation, pests, quarantine, species transfer, biological control.

INTRODUCTION

The considerable cost (U.S.$ 81.7 million; FAO 1992) and sophisticated effort required to eradicate New World screwworm, Cochliomyia hominivorax (Coquerel) (Diptera: Calliphoridae), accidentally accompanying sheep into Libya in 1988 (Beesley 1991; Anon. 1992), should amply illustrate the risk and potential consequences of international traffic and exchange of goods between countries. The literature abounds with examples of exotic pathogens or pests entering new countries, often as a result of inadequate screening, pre-treatment or quarantine. This has resulted in the spread of vectors (Mertins & Schlater 1991; Goh et al. 1985; Norval et al. 1991), disease agents (Verster et al. 1991; Whitfield et al. 1984; Lawrence 1991) and pests (Braack 1991). Natural dispersal and epidemics unrelated to human cultural practice also occur, examples being the translocation of potential disease vectors on migrating birds (Kaiser & Hoogstraal 1958; Hoogstraal et al. 1964) and the devastating late-nineteenth century spread of rinderpest through Africa (Scott 1981; Plowright 1982). Deliberate introductions have also occurred, dating back to at least the previous century, usually as specifically-targeted biocontrol programmes where selected narrow host-range predators or parasites are introduced to achieve reduction in numbers of alien pests (Petty 1947).

The effects of such deliberate introductions have, in most cases, been positive (Samways 1988), although in some instances have had disastrous consequences, the introduction into Australia of rabbits (for hunting) and frogs (to control beetle larvae in cane fields) being well known examples.

Aside from any direct impact of the introduction of new species, such as losses through disease, parasitism or consumption of agricultural products, there is the potentially greater long-term risk of genetic interaction with indigenous species. The so-called ‘Africanized bees’ in South and Central America, which are more aggressive than the original indigenous species, is a case in point (Crawford 1990; Smith 1991).

This paper discusses exotic species that have become established in the Kruger National Park (KNP), South Africa, as a consequence of human activities, and also examines the issue of transfer of wildlife and their associated parasites within and between countries. The data are summarized in Table 1.

EXOTIC ARTHROPODS IN THE KRUGER NATIONAL PARK

Acarina

The establishment of black and white rhinoceroses in KNP is a particularly good example of the range of non-target passengers that can accompany such hosts. Through hunting, white rhinoceroses, Ceratotherium simum (Burchell), became extinct in the Transvaal in 1896 (Pienaar et al. 1992) and black rhinoceros, Diceros bicornis (Linnaeus), by 1940 (Hall-Martin 1988). White rhinoceroses were reintroduced into KNP from the Umfolozi Game Reserve in Natal over a 12-year period commencing in 1961, the total number of animals imported being 345 (Pienaar et al. 1992). Twenty black rhinoceroses were reintroduced into KNP from Natal in 1971, followed by 12 more from Zimbabwe in 1972 and additional specimens from Natal in ensuing years, totalling 76 successfully reintroduced animals (Hall-Martin 1988; Pienaar, pers. comm.). All rhinoceroses were released in the southern half of the Park, mostly south of the Sabie River. Populations of both black and white rhinoceroses are increasing (about 8 % p.a.), the black rhinoceroses total in KNP for August 1993 being 230 animals and white rhinoceroses totalling about 1876 individuals (Pienaar, pers. comm.).

Questing adults of the so-called rhino tick, Dermacentor rhinocerinus (Denny) (Ixodidae), are commonly encountered on grass stems throughout the southwestern part of KNP where a high density of rhinoceroses occurs. Although little is known of the general biology of D. rhinocerinus, it has not been recorded from 542 other mammal hosts of all sizes intensively examined for parasites and occurring sympatrically with both black and white rhinoceroses (Horak et al. 1983a,b, 1984, 1987, 1988, 1992, 1993). In the literature it is recorded as being host-specific to black and white rhinoceroses, with infrequent records from other hosts (Matthysse & Colbo 1987). Since rhinoceroses were extinct in KNP and the entire Transvaal for several decades, D. rhinocerinus probably became re-established in KNP through passive transfer with rhinoceroses when these animals were reintroduced during the 1960s.

Rhipicephalus maculatus Neumann (Ixodidae) is another tick apparently introduced into KNP through host translocation. During a routine monthly monitoring programme of off-host tick populations in the southern KNP, a single nymph of R. maculatus was found in the area between Lower Sabie and Crocodile Bridge. In February 1992 inspectors of the State Veterinary Department at Skukuza collected an engorged female and a male R. maculatus from an elephant culled near Sekurakwane (24.58S 31.16E). This species is endemic to Zululand where it is common on nyala, bushpig, buffalo and a range of other animals (Horak et al. 1983a, 1991b). It is likely that a small founding population of R. maculatus was introduced from Zululand either with translocated rhinoceroses or with 20 nyala released along the Sabie River in 1980. Despite their apparent low numbers, R. maculatus must be well established, as suggested by the presence of an adult male and a female on the elephant at Sekurakwane.

The tick Hyalomma marginatum turanicum Pomerantsev (Ixodidae) is not indigenous to KNP, being essentially confined to more arid zones in South Africa, such as the Karoo (Howell et al. 1978; Horak et al. 1991a; Walker 1991). During March 1988 a single questing adult was collected in the northern KNP during a tick survey covering the entire Park (Spickett et al. 1991).

During surveys in 1989 on water hyacinth, Eichhornia crassipes (Martius) Solms-Laubach, in the Crocodile River, the exotic mite Orthogonaluma terebrantis Wallwork (Galumnidae) was found in large numbers on hyacinths in the Van Graaf Dam (31.38S 25.36E) (Cilliers, pers. comm.). This phytophagous mite had previously been released in Egypt and Zambie in unsuccessful attempts at biological control of E. crassipes, and its presence in South Africa was unexpected (Cilliers 1991a). A subpopulation of these mites from the Crocodile River was released on 30 March 1993 on water hyacinth on the Letaba River below the Engelhardt Dam (23.50S 31.37E).

Lepidoptera

Sour prickly pear, Opuntia stricta Haworth, was introduced into KNP during the first half of this century for use as an ornamental and food plant at Skukuza (24.59S 31.35E). From here it was dispersed by animals and is currently established over a large area exceeding 10 000 ha in the vicinity of this camp. Almost four million plants were treated during herbicidal or mechanical eradication campaigns during the 1980s without achieving effective control. Approximately 2000 newly emerged Cactoblastis cactorum (Bergroth) (Pyralidae) caterpillars from the Graaff-
Reinet/Uitenhage area were released on O. stricta near Skukuza in March 1988 to complement these eradication programmes. A second release of 200 egg-sticks, with an average of 80 eggs per stick, took place in March 1990. The original parental stock of these moths was from Australia, which in turn originated from Argentina (Moran & Zimmerman 1991; Pettey 1947). A successfully breeding population has established but with a disappointingly low detrimental effect on fecundity and spread of O. stricta. Young plants appear to be most vulnerable to insect damage.

During a survey of phytophagous insects that attack the exotic weed Lantana camara Linnaeus in the southern KNP in January 1990, Cilliers (1990) found evidence of the blotch leafminer, Pseudopyrausta acutangulalis (Sneller) (Pyralidae). This insect is endemic to Mexico and although it is widespread in South Africa, no records exist of its release in this country. It occurs only on L. camara but does not effect sufficient damage to be an effective biocontrol agent.

**Diptera**

*Gyrostigma rhinocerontis* (Hope) is a large fly (up to 35 mm in length) of the family Gasterophilidae. The larval stages are endoparasitic in the stomachs of both black and white rhinoceros in southern Africa and have not been recorded from any other host (Zumpt 1965). During the past ten years one of us (L.B.) has examined the stomach contents of nine white rhinoceros and two black rhinoceros in KNP; each animal had large numbers of *G. rhinocerontis* larvae in the stomach. Since this species is host-specific to rhinoceros, it must have been introduced into KNP along with its host, probably during the 1960s. Adult *G. rhinocerontis* are rare; they have rudimentary, non-functional mouthparts and survive only a few days, sufficient to find a mate, copulate and lay eggs. The cream-coloured eggs are laid around the base of the horns of the rhinoceros or in clumps laterally or elsewhere on the head. It is therefore likely that *G. rhinocerontis* entered KNP in the egg-stage on rhinoceros and also as larvae in animals introduced from Natal or Zimbabwe.

*Rhinomusca dutoiti* Zumpt is a large biting fly of the family Muscidae (Stomoxyinae). They are commonly found on white rhinoceros especially, but also black rhinoceros in KNP and Natal, often in large numbers (> 100) laterally and dorsally on the body (Braack, unpubl.). These flies are particularly attracted to and feed avidly at small lesions with serous exudations on the body.

Zumpt (1973) suggests a host preference for white rhinoceros by *R. dutoiti*, although he also says that he 'found that they never attacked humans, but were occasionally caught on bait-cattle used in tsetse research.' In KNP we have collected flies off several hundred animals (tentrapped over drug-immobilized hosts or sweep-net sampling off drug-darted animals), including significant numbers (> 100) of rhinoceros, elephant, buffalo and most of the other species of large mammals. *Rhinomusca dutoiti* has never been recorded on any animal other than black or white rhinoceros. Furthermore, during monthly sampling of dung of white rhinoceros, elephant, buffalo and blue wildebeest over a 12-month period and rearing of flies breeding in the dung, *R. dutoiti* was found to breed exclusively in rhinoceros dung (Braack, Kappmeier & Meiswinkel, unpubl.). Evidence therefore suggests that this fly can exist only in the presence of rhinoceros and, after becoming locally extinct in the Transvaal along with its host earlier this century, was reintroduced into KNP probably with rhinoceros introduced from Natal in the 1960s. Since the adults have preferred periods for feeding and resting on the rhinoceros and do not remain on the hosts the entire day (Braack, unpubl.), they were probably not transferred from Natal as adults, but as eggs in dung deposited in the transfer crates in Natal.

*Chrysomya megacephala* (Fabricius) (Calliphoridae) is a synanthropic blow fly also known as the Oriental latrine fly which is endemic to southeast Asia (Kurahashi 1978, 1982). During the 1970s and 1980s it rapidly invaded and established itself in various parts of South and North America and Africa (Laurence 1986; Greenberg 1988; Wells 1991). It is a pest by aggregating and laying eggs on fresh fish at marketplaces (Esser 1990), can be a nuisance through abundance on dog faeces and garbage in proximity to humans (Wells 1991), is potentially important in mechanical transmission of helminthic and other disease agents (Greenberg 1973; Monzon et al. 1991), and has been known to cause human myiasis (Lee & Yong 1991). It was first recorded in South Africa along the southwestern Cape coast in 1978 (Prins 1979) and by 1984 it was established in Skukuza (Braack 1991). Although entry of this exotic species into KNP was almost certainly through natural dispersal, it must have reached the proximity of KNP through human
activity, most likely from ships at Maputo harbour, 140 km from Skukuza (Braack 1991). This distance is well within the dispersal range of even a single generation of many calliphorid species (Braack & Retief 1986).

During a survey of phytophagous insects utilizing the exotic weed *L. camara* in the southern KNP in January 1990, Cilliers (1990) found that *Ophiomyia lantanae* (Froggatt) (Agromyzidae) had established. This fly was not deliberately released in KNP, but dispersed either from East Africa or later stock introduced from Hawaii (provenance Mexico) into South Africa in 1961 (Cilliers & Neser 1991).

A small founding population of *Calcomyza lantanae* Frick (Agromyzidae) originating from Trinidad via Australia, was released as a potential biocontrol agent of *L. camara* along the Sabie River immediately west of Skukuza in 1985. No adults were found subsequently, but leafmining typical of the immature stages was observed on *L. camara* in January 1990 about 8 km downstream from the original release site (Cilliers 1990).

**Coleoptera**

The exotic species of beetles established in KNP were all deliberately introduced and released as part of biological control programmes against invasive, alien plants.

On 17 December 1985, 1454 *Neochetina eichhorniae* Warner (Curculionidae), imported from Australia, were placed on water hyacinth, *E. crassipes*, in the Van Graan Dam, Crocodile River, downstream of Malelane Gate. This population is flourishing and has spread at least 50 km from the original release site (Cilliers 1991a). Another 230 adult *N. eichhorniae* were released on *E. crassipes* in the Letaba River, below the Engelhardt Dam, on 29 August 1992.

Five hundred adult *Neohydronomus affinis* Hustache (Curculionidae), also imported from Australia, were released on 18 December 1985 at Nhlangaluwe (22.225 31.12E) (Pafuri Section) in a pan heavily infested with the aquatic plant *Pistia stratiotes* Linnaeus, a floating weed probably originating from South America but now an invader in many parts of the world, including South Africa and KNP (Cilliers 1987). A subpopulation of *N. affinis* was transferred in June 1986 from Nhlangaluwe to the nearby Dakamila Pan (22.225 31.15E), which was also heavily infested with *P. stratiotes* (Cilliers 1991c). Following successful results at these isolated pans, further releases of *N. affinis* on *P. stratiotes* at various sites in the Sabie River between Skukuza and Lower Sabie were carried out as follows: 1987 (100), 1988 (405), 1989 (400), 1990 (1000), 1992 (3368). Releases of this beetle on *P. stratiotes* were also effected at Orpen Dam (24.475 31.53E) in 1990 (635) and the Crocodile River (unrecorded site) (1991, unknown number). Localized but generally successful control of *P. stratiotes* has been achieved at these release sites.

Small populations of *Trichapion lativentre* (Béquin-Billecocq) (Apionidae) and *Neodiplogrammus quadriovittatus* (Olivier) (Curculionidae) were released in May 1988 along the Noord-Sand River, a tributary of the Sabie River, 800 metres west of the KNP boundary by Moran and Hoffmann (pers. comm.) in an attempt to initiate biocontrol of the aggressive exotic weed *Sesbania punicea* (Cavanilles) Bentham. Progeny of these released beetles have entered KNP along parts of the Sabie River harbouring *Sesbania*. A small colony of *N. quadriovittatus* was also released on the KNP boundary along the Tshutshe Spruit (23.575 31.10E) near Phalaborwa in 1992.

Approximately 150 adult *Cyrtobagous salviniae* Calder & Sands (Curculionidae), descendants of stock originally from Brazil (Cilliers 1991b), were released on South American water fern, *Salvinia molesta* Mitchell, infesting the Lower Sabie Dam (25.075 31.54E) during June 1992, with an additional release of another 150 adult weevils on 17 November 1992. These beetles have established and provide good biological control of *S. molesta*.

Small populations (<200 each) of the leaf beetles *Octotoma scabripennis* Guérin-Méneville and *Uroplata girardi* Pic (Chrysomelidae), originally endemic to Mexico and Brazil respectively, were released on *L. camara* in 1985 along the Sabie River on the western boundary of Skukuza, and in 1989 about 170 adults of each of these species were again released along the Nsikasi River in the southwestern KNP. The current status of these two species is uncertain as it is suspected that the initial populations may not have established themselves.

**Hemiptera**

A small population of *Teleonemia scrupulosa* Stål (Tingidae), from parental stock from Mexico via Hawaii, was released near Skukuza ‘after 1985’ as one of several potential biocontrol agents of the cosmopolitan weed *L. camara* (Cilliers 1990). It feeds on the flowers, young growth tips and
leaves, eventually causing defoliation, dieback of twigs and poor seed set. Its current status in KNP is uncertain.

*Orthezia insignis* Browne (Ortheziidae) occurs widely throughout South Africa and has been recorded on *L. camara* in the southern KNP (Cilliers 1990.) and on exotic plants in gardens in Skukuza (Braack, unpubl.). *Orthezia insignis* is thought to have been introduced into South Africa (origin unknown) and currently has an almost country-wide distribution (Scholtz & Holm 1985).

**Orthoptera**

There are at least three species of non-indigenous crickets (Gryllidae) that are established in KNP, and which are likely to have been inadvertently introduced into this area through human activity (Toms, pers. comm.). The first species is the widespread and common garden cricket, *Gryllus bimaculatus* De Geer. It is present in gardens amongst leaf litter and under rocks or logs in many of the tourist camps.

*Gryllodes supplicans* (Walker) is also widespread in KNP and common in tourist camps, usually in cracks and crevices in rocks and even bituminized roads. It is a cosmopolitan species frequently encountered on ships.

*Acanthogryllus fortipes* (Walker) appears to be strictly associated with large expanses of lawn and is fairly common in many of the camps in KNP. It has an extensive distribution throughout southern Africa.

The status of *Gymnogryllus compactus* (Walker) is uncertain: it may have been introduced into KNP from more tropical areas of Africa, but may also be a low-density indigenous inhabitant. Despite extensive surveys elsewhere in KNP, Otte et al. (1988) recorded this species only from lawns at Skukuza.

**Blattodea**

Four species of cockroaches, collected in residential units in KNP since 1989, are household pests in many parts of the world.

The Australian cockroach, *Periplaneta australasiae* (Fabricius), is thought to have originated in tropical Africa but has been widely dispersed and established in virtually all the tropical and subtropical countries of the world. It is very common in houses in Skukuza where it maintains year-round activity, being present in low numbers in winter but abundant in the warmer months. Specimens are infrequently encountered in flowerbeds adjoining houses, but we have never recorded this species, or any of the other species mentioned below, in areas away from human dwellings.

The German cockroach, *Blatella germanica* (Linnaeus), was first reported in Skukuza in the spring of 1991. This species became abundant in houses during the following summer and has maintained a constant presence although with decreased activity during winter. *Blatella germanica* is thought to have originated from northeast Africa (Cornwell 1968) or Asia (Atkinson et al. 1991) but has become a virtually ubiquitous household pest (Rehn 1945).

*Pycnoscelus indicus* (Fabricius) has a cosmotropical distribution and is present in low numbers in houses in Skukuza and tourist huts in Letaba.

The cinereous cockroach, *Nauphoeta cinerea* (Olivier), also has a cosmotropical distribution but with its probable provenance being Africa. It is a 'semi-pest' usually transported with fruit into new countries (Marshall, pers. comm.) and is normally present in low numbers. One of us (L.B.) collected a single specimen of this species in KNP, from a hut at Shingwedzi during 1989.

Cockroach populations within houses in KNP were to a large extent controlled by the twice-yearly domiciliary spraying campaign sponsored by the South African Department of National Health & Population Development, but this routine spraying programme with residual insecticides (e.g. Cyfluthrin) was discontinued in 1991. Within the same year there was an apparent marked increase of cockroaches in residential units, which resulted in requests from staff for control measures. It is likely that *B. germanica* was present in KNP long before 1991, but had been kept at very low population numbers by the anti-malarial spraying campaign.

**Thysanura**

The fishmoth, *Ctenolepisma longicaudata* Escherich, is occasionally encountered in residential units in Skukuza, and there is at least one record from Satara. This species, introduced into South Africa from Europe before 1900 (Scholtz & Holm 1985; Irish 1987), is associated with human dwellings in many parts of the world and is usually transferred with books or other items in packing crates (Irish, pers. comm.). It was common in houses during the early 1980s but is currently rarely encountered, presumably a consequence of
<table>
<thead>
<tr>
<th>Organism</th>
<th>Mode of introduction</th>
<th>Origin/Source</th>
<th>Ecological niche</th>
<th>Population status</th>
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<tr>
<td><strong>ACARINA</strong></td>
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<tr>
<td>Ixodidae</td>
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<tr>
<td><em>Dermacentor rhinocerinus</em> (Denny)</td>
<td>Attached to black and/or white rhinoceros</td>
<td>Natal, South Africa</td>
<td>Ectoparasite on black and white rhinoceros</td>
<td>Established; common</td>
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<tr>
<td><em>Hyalomma marginatum turanicum</em> Pomerantsev</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Ectoparasite on wildlife</td>
<td>Unknown (single record)</td>
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<tr>
<td><em>Rhipicephalus maculatus</em> Neumann</td>
<td>Attached to nyala or black/white rhinoceros</td>
<td>Probably Natal, South Africa</td>
<td>Ectoparasite on wildlife</td>
<td>Established; uncommon</td>
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<td>Galumnidae</td>
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<tr>
<td><em>Orthogalumna terebrantis</em> Wallwork</td>
<td>Natural dispersal</td>
<td>Unknown</td>
<td>Phytophagous on <em>Eichhornia crassipes</em></td>
<td>Established; common</td>
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<td><strong>INSECTA</strong></td>
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<tr>
<td><strong>THYSANURA</strong></td>
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<td>Lepismatidae</td>
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<td><em>Ctenolepisma longicaudata</em> Escherich</td>
<td>Natural dispersal</td>
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<td>Domestic synanthrope</td>
<td>Established; uncommon</td>
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<td><strong>BLATTODEA</strong></td>
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<td><em>Nauphoeta cinerea</em> (Olivier)</td>
<td>Natural dispersal</td>
<td>Unknown</td>
<td>Cosmotropical synanthrope</td>
<td>Established; uncommon</td>
</tr>
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<td><em>Pycnoscelus indicus</em> (Fabricius)</td>
<td>Natural dispersal</td>
<td>Unknown</td>
<td>Cosmotropical synanthrope</td>
<td>Established; uncommon</td>
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<td>Natural dispersal</td>
<td>Unknown</td>
<td>Tropical/subtropical synanthrope</td>
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<td>Blattellidae</td>
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<td><em>Blatella germanica</em> (Linnaeus)</td>
<td>Natural dispersal</td>
<td>Unknown</td>
<td>Near-cosmopolitan synanthrope</td>
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<tr>
<td><strong>ORTHOPTERA</strong></td>
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<td>Gryllidae</td>
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<td><em>Acanthogryllus fortipes</em> (Walker)</td>
<td>Natural dispersal</td>
<td>Unknown</td>
<td>Inhabits lawns</td>
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<tr>
<td><em>Gryllodes supplicans</em> (Walker)</td>
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<td>Unknown</td>
<td>In cracks in rocks and road surfaces</td>
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<td><em>Gryllus binaculatus</em> De Geer</td>
<td>Natural dispersal</td>
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<td>Tunnels within and feeds on lawn-grass</td>
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<td><strong>HEMIPTERA</strong></td>
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<td>Tingidae</td>
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<td><em>Teleonemia scrupulosa</em> (Stål)</td>
<td>Deliberate release on <em>Lantana camara</em></td>
<td>Mexico via Hawaii</td>
<td>Phytophagous on <em>Lantana camara</em></td>
<td>Uncertain</td>
</tr>
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<td>Table 1 – continued</td>
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</table>

| Ortheziidae | 
| Orthezia insignis Browne | Unintentionally on ornamental garden plants? | Unknown | Sap-feeder on exotic garden plants | Established; common |

**COLEOPTERA**

| Chrysomelidae | 
| Octotoma scabripennis Guérin-Méneville | Deliberate release on Lantana camara | Mexico | Phytophagous on Lantana camara | Uncertain |
| Uroplata girardi Pic | Deliberate release on Lantana camara | Brazil | Phytophagous on Lantana camara | Uncertain |

| Curculionidae | 
| Cyrtobagous salviniae Calder & Sands | Deliberate release on Salvinia molesta | Brazil | Phytophagous on Salvinia molesta | Established; common |
| Neochetina eichhorniae Warner | Deliberate release on Eichhornia crassipes | Australia | Phytophagous on Eichhornia crassipes | Established; common |
| Neodiologrannus quadrivittatus (Olivier) | Deliberate release on Sesbania punicea | Unknown | Phytophagous on Sesbania punicea | Uncertain |
| Neohydronomus affinis Hustache | Deliberate release on Pistia stratiotes | Australia | Phytophagous on Pistia stratiotes | Established; common |
| Apionidae | 
| Trichapion lativentre (Béquin-Billecocq) | Deliberate release on Sesbania punicea | Unknown | Phytophagous on Sesbania punicea | Uncertain |

**DIPTERA**

| Agromyzidae | 
| Calcomyza lantanae Frick | Deliberate release on Lantana camara | Trinidad via Australia | Leafminer on Lantana camara | Uncertain |
| Ophiomyia lantanae (Froggatt) | Natural dispersal | East Africa or Mexico via Hawaii | Phytophagous on Lantana camara | Established; common |

| Muscidae | 
| Rhinomusca dutolit Zumpt | Eggs in rhinoceroses dung | Natal, South Africa | Haematophagous on rhinoceroses | Established; common |

| Calliphoridae | 
| Chrysomyia megacephaia (Fabricius) | Natural dispersal | Unknown | Breeds in organic waste | Established; common |

| Gasterophilidae | 
| Gyrostigma rhinocerontis (Hope) | Eggs and/or larvae with translocated rhinoceros | Natal, South Africa | Endoparasitic in rhinoceroses | Established; common |

**LEPIDOPTERA**

| Pyralidae | 
| Cactoblastis cactorum (Bergroth) | Deliberate release on Opuntia stricta | Graaff-Reinet/Uitenhage ex Australia | Caterpillars feed in cladodes of plant | Established; common |
| Pseudopyrausta acutangulalis (Sneller) | Natural dispersal | Unknown | Leafminer in Lantana camara | Established; uncommon |

1. Established = a successfully breeding, viable population; Common = in the area of distribution of the species in KNP, individuals are readily encountered upon searching; Uncommon = concerted effort must be made to find very low numbers of individuals.
anti-mosquito indoor insecticidal spraying during the latter half of the 1980s. As this spraying has been discontinued the species will probably regain its previous abundance.

DISCUSSION

The inadvertent introduction and establishment of a fairly wide range of exotic arthropods in KNP has fortunately not had serious consequences.

Although we have not been able to find proof in the scientific literature, some veterinarians hold the opinion that retaining parasites on their hosts is advantageous as it stimulates the host immune system, thereby improving host vigour and ability to withstand further parasite challenge. The ramifications and uncertainty associated with this approach have possibly been the most important factors contributing to the lack of a clear, standard policy regarding deparasitizing wild vertebrates before translocation. Veterinary practice in this regard currently appears to adhere to prevailing inadequate legal requirements rather than a rational, comprehensive strategy that includes conservation considerations. Animals transferred across international boundaries are usually deparasitized, whereas wildlife moved within South African borders, irrespective of distance or locality, are only rarely subjected to such treatment (Henwood 1989; Raath & Hall-Martin 1989). We suggest that the decision should be based on the potential detrimental effects, rather than the possible but unproven advantages. These disadvantages include, amongst others: retention of parasites which may increase and kill an immunocompromised host as a result of stress through capture, captivity and transfer (e.g. *Trypanosoma*); range extension of a parasite passively transferred with a relocated host, with possible serious consequences for other animals or humans (e.g. *C. hominivorax*; Lyme disease, *Borreilia burgdorferi*); transfer to a new geographic region where the arthropod may serve as an efficient additional vector of indigenous pathogens (e.g. *Anopheles gambiae* Giles (Diptera: Culicidae) vectoring malaria following introduction into South America); introduction of a pathogen into a previously disease-free region where suitable vectors exist; translocation of both the arthropod vector and the pathogen it transmits (e.g. *Amblyomma variegatum* (Fabricius) (Ixodidae) and *Cowdria ruminantium* (Cowdry) (Ehrlichiae) from Africa to the Caribbean islands as described by Barré et al. (1987)); the transfer of an otherwise benign parasite from a well-adapted host to a fatally susceptible host following introduction of animals infected by e.g. *Trypanosoma*, *Theileria*; hybridization or loss of genetic 'purity.'

This latter aspect of maintenance of gene pool purity in geographically separated populations of the same species has received some attention when transferring vertebrate animals, such as attempts to ensure that rhinoceros transferred to a particular area retain genetic integrity by having a common geographic origin (Brooks 1989). In a world where conservation areas are relatively few and concern for preservation of biodiversity is rising, this insidious effect of genetic 'dilution' or hybridization should not be overlooked, it being as relevant to invertebrates as vertebrates.

In conclusion, we hope that game farmers, conservation bodies and other organizations involved in the capture and transfer of wildlife will routinely adopt measures to minimize the risk of passive transport of other organisms, not only internal and external parasites, but also the immature stages of beetles, flies and other organisms in faeces often present inside transport crates.

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