A NON-INDIGENOUS HALACARID SPECIES IN VICTORIA, SOUTHEASTERN AUSTRALIA, *ISOBACTRUS UNISCUTATUS* (RHOMBOGNATHINAE, HALACARIDAE, ACARI)

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In a temperate mangrove forest in Victoria, Australia, the mite fauna was dominated by a single halacarid species, the rhombognathine *Isobactrus uniscutatus* (Viets, 1939). The species is otherwise recorded from the northeastern Atlantic Ocean and adjacent basins. The source region of the species, Australia or Europe, and means of dispersal are discussed. *Isobactrus uniscutatus* is likely to come from northern Europe and might have been transported to Australia with hard ballast a century ago.

Key words: Marine mite, *Isobactrus*, introduced species, Australia, origin, means of dispersal

WITH world-wide travel and transport of goods, organisms are often unintentionally or intentionally introduced into new areas. One of the most important vectors is the content of ballast tanks of cargo vessels. According to recent calculations, several thousand species are transported by ship each day (Carlton & Geller 1993; Gollasch 1996). The rate of successful colonization of translocated microorganisms, plants or animals released in a new biogeographical region is unknown and many invasions might escape notice for long periods or require repeated inoculations for successful establishment. According to recent surveys of macrofauna in the ports in Victoria, shipping channels and spoil ground, about one-tenth of the marine species are non-indigenous (Cohen et al. 2001; Hewitt et al. 2004). Meiofaunal taxa such as mites are not included in these surveys.

The major marine mite family, the Halacaridae, presently includes approximately 1000 described species; beside the marine ones about 50 species are from freshwater. The mites are small-sized and exclusively benthic. Marine halacarids are present from the upper littoral to deep sea trenches, the freshwater ones from coastal zones to an altitude of 5000m. Halacarids are expected to be slow colonizers, they have no resting or planktonic stage and most species display low fecundity.

ISOBACTRUS UNISCUTATUS, A SPECIES NEW TO AUSTRALIA

Recent investigations on the meiofauna in *Avicennia* mangroves on the bank of the Barwon estuary, in the central coastal region of temperate southern Victoria, Australia, concentrated on the composition of the fauna in the mud and on the pneumatophores (Gwyther 2000). In the fouling on the pneumatophores, consisting of barnacles, algae or a combination of these epibionts, there were large numbers of marine mites, mainly halacarid mites (Halacaridae, Prostigmata) and occasionally species of gamasids (Mesostigmata) and oribatids (Ameronothroidea, Oribatida). The halacarid fauna in turn was dominated by a single species, *Isobactrus uniscutatus* (Viets 1939), a representative of the halacarid subfamily Rhombognathinae. *Rhombognathus*, another rhombognathine genus, was present though rare (Gwyther & Fairweather 2002).

SHAPE, BIOLOGY AND DISTRIBUTION OF *ISOBACTRUS UNISCUTATUS*

Isobactrus uniscutatus was first described from the Adriatic Sea of the Mediterranean (Viets 1939). Later it proved to be very abundant in the upper littoral zone in the northeastern Atlantic and North Sea (Bartsch 1972, 1976, 1978, 1979a; Green & MacQuitty 1987;

Siemer 1996). Recently the species was taken in the southwestern Pacific, in Victoria, Australia.

Adults of *I. uniscutatus* have a length of about 350–440 µm (idiosomal length), the Australian individuals have a length of 370–425 µm. The idiosoma is almost dark green, generally has a white median line and three very small red eye spots, a single anterior one near the tip of the idiosoma and a pair of lateral spots. The four pairs of legs are transparent and six-segmented; their tarsi bear smooth claws and conspicuously long and slender setae. The short gnathosoma, with its small palps and chelicerae, is largely hidden beneath the anterior end of the idiosoma. *Isobactrus uniscutatus* is algivorous, as are all other rhombognathines, and the dark green colour of the idiosoma is due to the colour of the gut with remnants of the diet showing through the transparent integument. The outlines of the long median dorsal shield (Figure 1A), the pair of short, bean-shaped ocular plates and the epimeral plates are discernible only in cleared specimens, from which the dark gut content is removed. Details of clearing halacarid mites and adequate mounting media for temporary and permanent mounts are described in Green & MacQuitty (1987).

Females and males are similar from the dorsal aspect; on the ventral side the shape of the epimeral plates is the same but the sexes differ in the genital region. The male genital opening is surrounded by a plate that bears numerous setae and two pairs of genital acetabula moved to a position posterior to the genital opening (Figure 1B). The female has three pairs of setae outside the genital plate (Figure 1C) and, as in other *Isobactrus* species, the genital acetabula are inside a cavity which is guarded by the genital sclerites.

In common with congeneric species, *I. uniscutatus* passes through four free-living juvenile instars before the adults hatch. The four instars are a larva and three nymphs, the proto-, deuto- and tritonymph. The larvae are much smaller than the adults, transparent when just hatched and, in contrast to the following instars, they bear only three pairs of legs. Aside from the smaller size, the nymphs resemble the adults; morphological differences are obvious in cleared individuals. Juveniles have no fused dorsal shield but the anterior and posterior dorsal plate separated. A genital opening is lacking, instead there is a small genital plate with one or two pairs of internal genital acetabula.

Juveniles and adults live in the same substratum wherein spermatophores and eggs are deposited. Resting, planktonic or dispersal stages are not known. Whereas most halacarids have a one-year life cycle, the genus *Isobactrus* develops quickly and can run through two generations per year (Bartsch 1972; Pugh & King 1986). The maximum number of eggs per female is 32 (Siemer 1996).

Isobactrus uniscutatus lives in and somewhat below the high water edge and is rare below the midwater line. It is a very eurytopic halacarid. In the Mediterranean, from where it was first recorded, three of the four collecting sites were strongly influenced by freshwater (Viets 1939). In the Eastern Atlantic and North Sea coast, the species is regularly taken within a salinity range from almost fresh to about 28 ‰. At about 25–28 ‰ salinity, *I. uniscutatus* is present near the high water mark, amongst lichens and films of filamentous or thin, tubular algae on stones, wooden pilings or entangled between the muddy surface of a salt marsh. The species is known to penetrate into the very diluted brackish and fresh water zone, in the river Elbe (northern Germany) into an area of less than 0.5 S‰ where typical marine algae are lacking (Bartsch 1972, 1974, 1981). Here, *I. uniscutatus* inhabits the moss *Cinclidotus* sp. The highest densities in the Weser estuary (northern Germany), with 1094 individuals per 10 cm^2, were reached in the late summer in Dedesdorf, in a predominantly oligohaline brackish-water zone (Siemer 1996). *Isobactrus uniscutatus* is found in communities not or moderately exposed to wave action but not in areas exposed to severe swell.

In the intertidal zone of the river Barwon estuary in southern Victoria, *Isobactrus uniscutatus* was abundant on fouled pneumatophores where it reached densities of 38 individuals per 10 cm^2.

As demonstrated in experiments (Siemer 1996), *I. uniscutatus* can complete a life cycle, from the egg to deposition of eggs of the raised female, within 89 days. At summer temperature (20°C) development is quickest at 15 S‰. At lower temperature the development is retarded, at 5°C it is almost stopped. When kept at salinity of 1 or 30 ‰, the time of development is 1.5 times longer than that at 15 ‰ (Siemer 1996). The dense population of *I. uniscutatus* in the freshwater zone of the river Elbe near Hamburg inplies that the species can thrive and reproduce at less than 0.5 S‰.

Short-time exposure to environmental challenges, far beyond the given limits necessary for development and reproduction, are tolerated without any obvious damage. Salinity beyond 50 ‰ is survived in an inactive state for several days; the individuals quickly recover when returned into their habitat salinity (Bartsch 1974). *Isobactrus uniscutatus* also proved to be resistant to high temperatures (Bartsch 1974). A temperature of about 39–40°C is normally not reached at the German coast, even on a very sunny summer day after hours of intense sun radiation on a quickly drying substratum. Individuals of *I. uniscutatus* exposed to such temperatures quickly turn into an inactive state and survive (Bartsch 1974). Freezing is tolerated as well.

Though being an aquatic organism, *I. uniscutatus* can survive long-term desiccation. In experiments of 12 days exposure to air, without wetting by splash, 40 % of the animals in a test recovered (Bartsch 1974).

Siemer (1996) demonstrated that *I. uniscutatus* can be raised on a diet of *Blidingia*, a tubulose green algae often dominant in the upper littoral in marine and brackish water. The diet in the field is certainly not restricted to a single algal species but is diverse and, in adaptation to the relevant habitat, includes several food items. Beside algae, fungi or even carcasses may attract and be used by the mite.

ECOLOGY OF *ISOBACTRUS UNISCUTATUS* IN THE RIVER BARWON ESTUARY

The Barwon estuary is in the temperate southern Victorian coast of Australia (38°17'S, 144°30'E). The tidal amplitude is 1.8 m. In the upper tidal area, the mudflats are covered with mangroves, with a single tree species, *Avicennia marina* (Forsskål) Vierhapper, 1907, whose pneumatophores extend almost 20 m seaward (Gwyther 2000). The generally dense coverage by epibionts consists of algae, barnacles or a mixture of both. On algal fouled pneumatophores marine mites represented 31% of the epiphytic meiofauna (Gwyther 2000), with *I. uniscutatus* being the numerically most important taxon. On pneumatophores fouled with

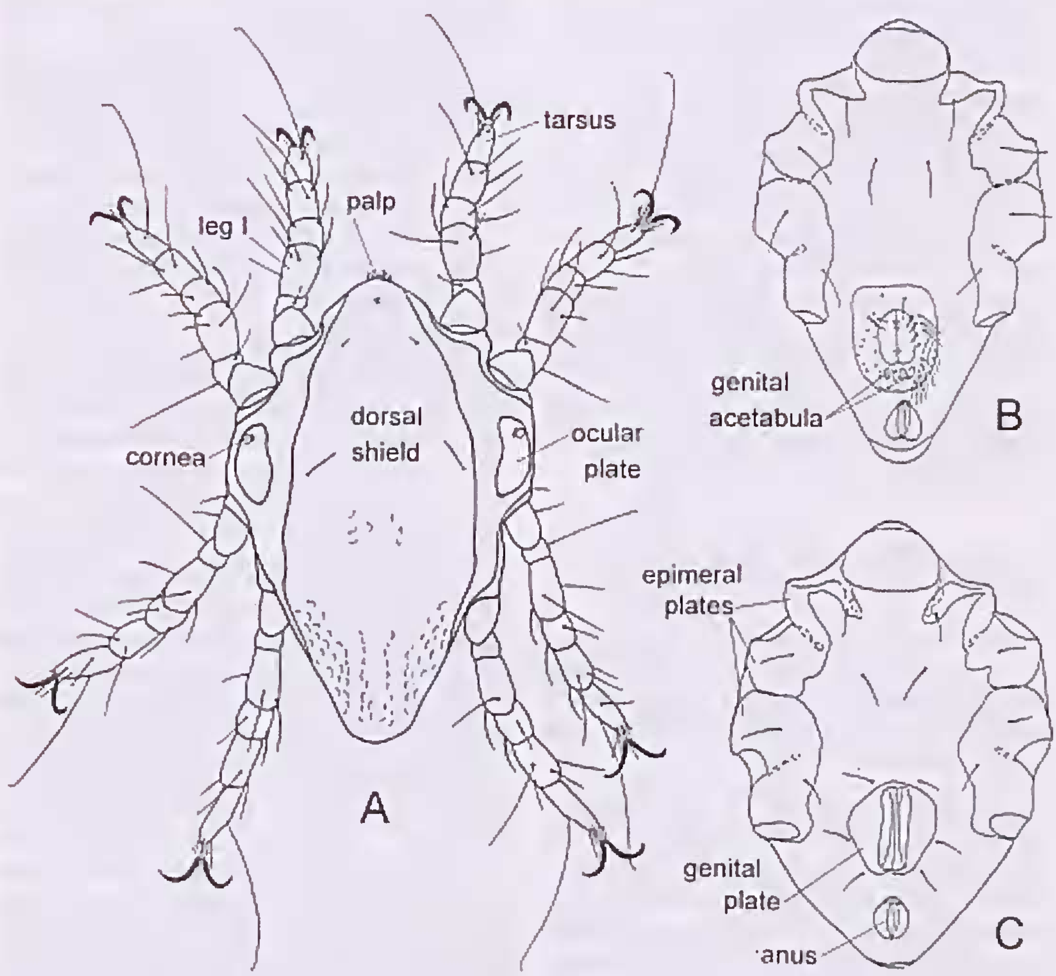

Fig. 1. *Isobactrus uniscutatus*, A, dorsal aspect; B, idiosoma, ventral aspect, male; C, idiosoma, ventral aspect, female.

barnacles, this single mite species comprised almost 91% of the epibiotic meiofauna. It reached densities of 500–1000 individuals per pneumatophore. Marine mites were rare in the muddy sediment and amongst the leaf litter of the forest floor.

THE GENUS *ISOBACTRUS*

At present, the genus *Isobactrus* contains 26 species. All records of *Isobactrus* are from near the water edge, the majority from areas regularly or irregularly emerged, from coastlines under tidal influence or basins with irregular oscillations. The genus is spread worldwide, present in almost all latitudes, from 75°N, on the coasts of Nowaja Semlja in the North Polar Sea, over warm and tropical shores (Galapagos Island, Micronesia) to the cold-temperate and sub-Antarctic (South America, South Georgia, Prince Edward Island, Kerguelen, Macquarie Island) (Bartsch 2003c).

More species of *Isobactrus* are recorded from the northern than from the southern hemisphere (Bartsch 2003c). In the North Atlantic and adjacent basins, *Isobactrus* often is present in high densities, whereas in tropical and southern hemisphere regions, *Isobactrus* seems to be rare. Three species have been previously recorded from Australia, *I. ponapensis* Abé, 1996 from the Great Barrier Reef, *I. australiensis* Bartsch, 2003 and *I. obesus* Bartsch, 1992 from tropical Western Australia (Bartsch 2000, 2003a). *Isobactrus uniscutatus* is the fourth *Isobactrus* species from Australia and the first from Victoria, and, in contrast to the other species, it lives in dense populations.

GEOGRAPHIC ORIGIN OF *ISOBACTRUS UNISCUTATUS* AND MEANS OF DISPERSAL

Isobactrus uniscutatus is believed to be no native Australian species but to have been transported from Europe to Australia; here it found a suitable habitat to colonize. The extent of its present distribution along the Victorian coastline is unknown.

The genus *Isobactrus* inhabits latitudes from 75°N to 55°S, but there are clear differences between species from the northern and southern hemisphere (Bartsch 2000, 2003c; Abé 2001). In species from the northern Atlantic and Pacific the anterior epimeral plates are small, the dorsal setae on the idiosoma are slender, and in a few species the number of setae is less than the five pairs present in the majority of all halacarids. Species from the warm-temperate and tropical Indo-West Pacific and the southern hemisphere have larger anterior epimeral plates, the species have five pairs of dorsal setae on the idiosoma but the setae are short and spur-like. Compared to congeners from the north, often the numbers of setae on the third and fourth leg segments are reduced. The species from cold-temperate and sub-Antarctic areas differ from species from the tropics by the large anterior epimeral plates being fused in the median and the presence of a dorsolateral seta on the third epimeral plate.

Abé (2001), after a phylogenetic analysis based on morphological characters, distinguished between three major groups which in turn proved to be bound to geographic regions. One group includes species of the northern seas, the Northern Pacific, Northern Atlantic and adjacent basins, another is restricted to the tropical/warm-temperate Indo-West Pacific region; these species in turn are distinct from those recorded from the cold southern hemisphere shores.

Isobactrus uniscutatus is a typical northern Atlantic species and, moreover, it shares several characters with *I. hutchinsoni* Newell, 1947, an eastern North American species (Newell 1947), characters not found in any of the other *Isobactrus* species (Bartsch 1979b, 2003c). We suggest that the presence of *I. uniscutatus* in Victoria most certainly is the result of human activity, and it is unlikely that it is a relict of a former fauna. This raises the questions of how and when this species arrived in Australia.

Mechanisms of transfer to foreign coastlines, for example to the Mediterranean and North America are summarized in Zibrowius (1991) and Ruiz et al. (1997). Vectors which can be excluded with respect to *I. uniscutatus* are: (1) transport by aquarium equipment: such a transport is thought to be responsible for long-distance spreading of the algae *Caulerpa taxiflora* (M. Vahl) C. Agardh, 1817 (Withgott 2002); (2) transport by marine packing material: organic packing material (algae) is used over short distances but certainly not in intercontinental journeys; (3) transport together with intentionally introduced species and equipment, e.g. together with organisms for aquaculture. Cultures from offshore areas are not expected be contaminated by *I. uniscutatus*, but there is a small chance that equipment in semi-enclosed bays or nearshore brackish-water areas is colonized by this halacarid and then transported.

The most important vector in unintentional translocation of marine organisms is transport by ship, either on the hull or with the contents in ballast tanks. In the case of *I. uniscutatus*, a recent transportation on the hull of a ship can be rejected because the halacarid fauna in harbours nowadays generally is poor (most likely due to frequent destruction of the habitat by abrasion, oil spill and other chemical pollutants) and even if some halacarid specimens should be able to settle amongst the fouling, they would be washed off during the passage from Europe to Australia. Transport in ballast water is unlikely, too, as halacarids have no planktonic stages. The number of species washed out from their habitats seems to be negligible, and, as mentioned above, the halacarid fauna in harbours is sparse. The mite mentioned by Carlton & Geller (1993) from ballast water is expected not to be a halacarid mite but one of the semiterrestrial or terrestrial living forms which now and then are found drifting near the shoreline (e.g. the mite mentioned by Armonies 1989).

Still, *I. uniscutatus* is likely to have been transported by ship. Prior to the middle of the 19th century, sand and boulders were used as ballast (Carlton 1985). Algae-covered stones and boulders from the shoreline, often stored in special areas, provided an ideal substratum for benthic meiofaunal organisms. As shown above, *I. uniscutatus* is at least in experiments resistant to a deteriorating environment, and a part of a founder population, with both female and male individuals, should have been able to survive transport by ship, wetted by splash now and then. As *I. uniscutatus* can live in a wide range of substrata, salinity, temperature, tidal emergence, and feed on different food items, it is likely that it found an unoccupied niche in a brackish-water environment. With its rather high rate of development, approximately 20 eggs per female and two or three generations a year, this halacarid species had a good chance to establish itself successfully in Australia.

DISTRIBUTION IN AUSTRALIA

At present, records of *Isobactrus uniscutatus* are restricted to the river Barwon estuary, Victoria. The mite is numerous amongst pneumatophores of the mangrove *Avicennia marina*. The extent of the geographic distribution westwards towards Spencer Gulf, or eastwards to the coast of New South Wales is not known. The species obviously has not reached Perth, Western Australia. During a short stay-over in the austral winter 2000, the first author (I.B.) examined the banks of the Swan River, expecting to find halacarid species adapted to the fluctuating salinity in the Swan river. The only mite species regularly present in the samples of algae and deposits between roots of *Juncus* was a representative of the halacarid genus *Copidognathus* (Bartsch 2003b). No *Isobactrus* species was collected. Should *I. uniscutatus* be transported into the mouth of the Swan river, it is likely to be able to become established as the mite fauna in the Swan river proved to be sparse and *I. uniscutatus* would not have to compete with any native halacarid species.

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