A taxonomic study of *Strongyloides* Grassi, 1879 (Nematoda) with special reference to *Strongyloides fuelleborni* von Linstow, 1905 in man in Papua New Guinea and the description of a new subspecies

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Abstract

The taxonomic position of a *Strongyloides* species parasitic in man in Papua New Guinea (PNG) that apparently resembled *S. fuelleborni* (a parasite of man and other primates in tropical Africa) has not been resolved since its discovery in 1973. The results of a morphological (by scanning electron microscopy) and morphometric study were considered together with the results of a separate isoenzyme electrophoretic study of the same material. The nature of the peri-vulval cuticle of the parasitic female and the position of the phasmidial pore of the free-living male were found to be of particular use in addressing this taxonomic problem. We concluded that the *Strongyloides* in Africa and PNG are subspecies of *S. fuelleborni*. We propose the name *S. fuelleborni kellyi* n. subsp. for the *Strongyloides* found in man in PNG.

Introduction

Before 1973 the known aetiological agents of human strongyloidiasis were *S. stercoralis* (Bavay, 1876) Stiles & Hassall, 1902 and *S. fuelleborni* von Linstow, 1905. *S. stercoralis* has a cosmopolitan distribution in warm climates (Pawlowski, 1989), whereas *S. fuelleborni* infects man and other primates in tropical Africa (Pampiglione & Ricciardi, 1972) and primates in Asia (Little, 1966a). Thirty-three percent of five *Macaca* species (700 examined) were found to be infected with *S. fuelleborni* (see Wong & Conrad, 1978). The only report of a human *S. fuelleborni* infection outside of Africa or PNG was of an American serviceman who had been stationed in Guadalcanal, Fiji, Bougainville and Leyete (Wallace et al., 1948). Whilst in Leyete he was in areas in which monkeys were abundant and he also had a pet monkey (*Macaca irus*).

In 1973 eggs of *Strongyloides* sp. were found in human stools collected in the Kiunga area of western Papua New Guinea (PNG) (Kelly & Voge, 1973). Treatment of an individual passing these eggs revealed numerous parasitic females of *Strongyloides* sp. in the post-treatment stools.

*S. stercoralis* characteristically passes larvae in the stool, thus suggesting that the *Strongyloides* in PNG was not *S. stercoralis*. *S. fuelleborni* passes eggs in the stool. However, there are no non-human primates on the island of New Guinea. *Kelly et al.*, (1976) examined all stages of the life-cycle, except the free-living male, and compared them with six other species. They concluded that the PNG *Strongyloides* very closely resembled *S.
fuellborni and S. cebus Darling, 1911, a parasite of South American non-human primates. It was thought that it was more likely to be S. fuellborni because it occurs in the eastern hemisphere and normally infects man in Africa. These authors thought that a definitive identification of this parasite could only be made after a more extensive study of further specimens. The PNG parasite has been provisionally termed S. cf. fuellborni (Ashford et al., 1981).

The absence of non-human primates from New Guinea, combined with the absence of non-S. stercoralis human strongyloidiasis in Asia between Africa and New Guinea raised intriguing questions on the origin and identity of the parasite. The new parasite is, therefore, either S. fuellborni, in which case its abundance in man in the absence of primates so far from Africa is surprising, or it is a closely related and surprisingly similar species which might have a zoonotic origin in one of the indigenous animals of New Guinea. In either case a considerable zoogeographical anomaly is presented by this interesting form.

The association of S. cf. fuellborni and a characteristic disease of young infants known locally as swollen belly syndrome (SBS) in PNG was first described by Ashford et al. (1978) and further confirmed by Vince et al. (1979). With SBS, infants of about two months of age acquire massive Strongyloides infections causing abdominal distension and respiratory distress. SBS is usually fatal unless anti-Strongyloides therapy is given (Vince et al., 1979). Accurate identification of S. cf. fuellborni is therefore important because if the New Guinea and African parasites are the same, it is possible that SBS occurs in Africa, but has not been recognised.

An isoenzyme study of 82 isolates of Strongyloides primarily from PNG man, PNG domestic animals (mainly pigs but also dogs and chickens), African non-human primates and isolates of S. stercoralis revealed a high level of inter-isolate heterogeneity (Viney & Ashford, 1990a). However, both cluster analysis and ordination of these data showed the existence of three discrete groups: (1) isolates from PNG domestic animals; (2) isolates of S. stercoralis; and (3) isolates from PNG man and African non-human primates. This suggested that the similarity between S. cf. fuellborni and Strongyloides from African non-human primates was greater than their similarity to the other isolates considered.

The morphological similarity between species of Strongyloides has frustrated taxonomic work on the genus. The main useful morphological characters are the stage, eggs or larvae, passed in the faeces, disposition of the ovaries (parallel to or spiralled with the intestine) of the parasitic female and the mouth shape in en face view of the parasitic female (Little, 1966a). Speare (1989) recognised that whilst current morphological criteria are able to distinguish many distinct species, other species cannot be separated. The previous morphological studies of S. cf. fuellborni using the primary morphological characters of Little (1966a) failed to resolve the taxonomic relationship between S. fuellborni and S. cf. fuellborni.

In this study we have compared S. fuellborni and S. cf. fuellborni using both morphometric and scanning electron microscope techniques primarily to resolve the taxonomic relationship between these parasites and secondarily to find characters useful in the taxonomy of the genus.

Comparison of size and body proportions of Strongyloides spp. have usually been of little use in identification mainly due to the wide variation shown within any one group of specimens and the absence of any significant difference between specimens of different origins. This problem was acknowledged by Sandground (1925). Premvati (1959) found that for the free-living female and third stage infective larvae (L3) the ranges of her own and other published measurements were within normal variation and thus the measurements could not be used to distinguish species. Little (1966a) considered that morphometrics were only exceptionally of use in differentiating species and then only in adjunct to other morphological characters.

Variation in the size, as well as the morphology, of the free-living generation has been found to be caused by different environmental conditions,