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A Review of the Genus *Echinococcus* Rudolphi, 1801

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A REVIEW OF THE GENUS ECHINOCOCCUS RUDOLPHI, 1801

BY

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AND

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During a recent investigation in Kenya, Echinococcus adults were obtained from 25 domestic dogs (Canis familiaris), three hyaenas (Crocuta crocuta), three wild hunting dogs (Lycaon pictus), and a jackal (Thos mesonelas) (Nelson and Rausch, 1963). In view of the occurrence of several species of Echinococcus reported from South Africa by Cameron (1926) and by Ortlepp (1934, 1937), a detailed study was necessary before the specific status of the Kenya material could be determined. We were fortunate in having available reference material from various parts of the world.

As a result of this study it is concluded that only three of the 11 named species of Echinococcus can be distinguished by purely morphological criteria, six are regarded as synonyms of E. granulosus (Batsch, 1786), and the status of two is uncertain.

In a previous appraisal, Rausch (1953) recognized the following species as valid: E. granulosus (Batsch, 1786), E. oligarthrus (Diesing, 1863), E. lycaontis Ortlepp, 1934, and E. felidis Ortlepp, 1937; also, the species later described as E. sibiricensis Rausch and Schiller, 1954, and subsequently found to be conspecific with E. multilocularis Leuckart, 1863, E. longimanubrius Cameron, 1926, and E. minimus Cameron, 1926, were listed by Rausch (1953) as species inquirendae, probably identical with E. granulosus. E. cameroni Ortlepp, 1934, was listed as a synonym of E. granulosus. The status of E. intermedius López-Neyra and Soler, 1943, and E. ortleppi López-Neyra and Soler, 1943, was not discussed. More recent studies indicate that some of these earlier conclusions were erroneous.

Echinococcus granulosus (Batsch, 1786)

This species has become widely distributed as a result of the extensive movement of domesticated animals. It is indigenous at high latitudes on the North American and Eurasian continents, where the life-cycle involves the wolf (Canis lupus) and various species of deer. A variable anatomy has been observed in both adults and larvae. Some of the variations recorded in the strobilar stage may have resulted from different methods of collection and preservation, and those in the larval stage are partly due to the effect of different host species. Among the possibly existing biological strains of E. granulosus only now being investigated, one, E. granulosus canadensis Cameron, 1960, has been named on the basis of its peculiar host-parasite relationships and possible serological differences. Measurements and morphological data for E. granulosus are summarized in Table I. Further data are to be found in the comparative study of material from Kenya (Nelson and Rausch, 1963).

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**Echinococcus multilocularis** Leuckart, 1863

In the strobilar stage this species is distinguished by the number and distribution of the testes, by the position of the genital pore, and by the form of the gravid uterus (Rausch, 1953; Rausch and Schiller, 1954; Vogel, 1957; Petrov and Chertkova, 1959). The alveolar form of the larva is distinctive. Comparative measurements of adult specimens from Germany, Alaska and Siberia are shown in Table II.

<table>
<thead>
<tr>
<th>Species</th>
<th>Place of origin</th>
<th>Length of strobila</th>
<th>No. of segments</th>
<th>Location of genital pore</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. granulosus</em></td>
<td>Australia (dog)</td>
<td>3'2 to 9'2</td>
<td>3</td>
<td>Near middle in mature segments; posterior to middle in gravid segments (Yamashita <em>et al.</em>, 1956; Plate I)</td>
</tr>
<tr>
<td><em>E. granulosus</em></td>
<td>England (dog)</td>
<td>Up to 7'4</td>
<td>4 or 5</td>
<td>Posterior to middle of segments</td>
</tr>
<tr>
<td><em>E. granulosus</em></td>
<td>Alaska (dog and Canis lupus)</td>
<td><em>1'5 to 6</em></td>
<td>Usually 2; sometimes 3 or more</td>
<td>Near middle in mature segments; posterior to middle in gravid segments</td>
</tr>
<tr>
<td><em>E. granulosus</em></td>
<td>Siberia (dog and Canis lupus)</td>
<td>2'7 to 5'4</td>
<td>3 to 4</td>
<td>In posterior half of segments</td>
</tr>
<tr>
<td><em>E. granulosus</em></td>
<td>Germany and Jugoslavia (dog)</td>
<td>2'1 to 5 (av. 3'36)</td>
<td>3</td>
<td>Near middle in mature segments; posterior to middle in gravid segments</td>
</tr>
<tr>
<td><em>E. granulosus</em></td>
<td>Kenya (dog)</td>
<td>2 to 3'5</td>
<td>3; sometimes 2 or 4</td>
<td>Near middle in mature segments; posterior to middle in gravid segments</td>
</tr>
</tbody>
</table>

* The validity of this figure is questionable; fully developed

*E. multilocularis* occurs at high latitudes in the northern hemisphere, from Canada and Alaska to Japan, Siberia and northern Europe. In nature, the adult cestodes are found in foxes (*Vulpes* and *Alopex*). The larvae develop in various species of microtine rodents.

Because of the unusual morphological and biological peculiarities of this cestode, a separate genus, *Alveococcus* Abuladze, 1959, has been proposed (Lukashenko and Zorikhina, 1961). While this proposal would seem to have at least as much merit as the establishment of separate genera for species of *Taenia sens. lat.*, it can be rejected on
similar grounds (Rausch, 1959). Morphological differences in the strobilar stage are not significant above the species level; the structure of the larva is distinctive, but, in view of the pleomorphism exhibited by the larval *E. granulosus* and of the inadequate knowledge of the larval stages of some other species of *Echinococcus*, it seems premature to erect a new genus on this basis. Host occurrence cannot be considered as a character of generic value.

of *E. granulosus* (all measurements in millimetres)

<table>
<thead>
<tr>
<th>Testes</th>
<th>Size of cirrus sac</th>
<th>Hooks</th>
<th>Source of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Distribution</td>
<td>No.</td>
<td>Size</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Large</td>
</tr>
<tr>
<td>45 to 65 (av. about 56)</td>
<td>From level of vitelline gland and ovary to near anterior margin of segment (Yamashita et al., 1956; Plate I)</td>
<td>0.240 to 0.288 long</td>
<td>32 to 40; often 32</td>
</tr>
<tr>
<td>48 to 64</td>
<td>Majority anterior to genital pore</td>
<td>—</td>
<td>30 to 36</td>
</tr>
<tr>
<td>45 to 65 (av. 56)</td>
<td>About equally distributed anterior and posterior to level of genital pore</td>
<td>Average 0.100 by 0.070</td>
<td>32 to 40</td>
</tr>
<tr>
<td>32 to 40</td>
<td>—</td>
<td>0.225 to 0.266 long</td>
<td>36 to 40; often 36</td>
</tr>
<tr>
<td>38 to 52 (av. 44)</td>
<td>About 2/3 of testes situated anterior to ovary</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>45 to 59 (av. 53)</td>
<td>Posterior margin to near anterior margin, confluent posterior to vitelline gland and ovary</td>
<td>Average 0.110 by 0.063</td>
<td>28 to 36</td>
</tr>
</tbody>
</table>

Strobilae of *E. granulosus* probably always exceed 2 mm. in length.

The differences in host-parasite relationships led Vogel (1957) to propose a subspecific designation, *E. multilocularis sibiricensis* Rausch and Schiller, 1954, for *E. multilocularis* in North America. Recently Shul'ts (1961) (cited by Shul’ts, 1962) has proposed the name *Alveococcus* (*Echinococcus*) *multilocularis kazakhensis* for a form of which the larva is reported to develop in sheep, but it is possible that this is a multicystic larva of *E. granulosus*. Further comparative experimental studies are required to determine reliable criteria for the recognition of distinct subspecies.
Echinococcus felidis (Ortlepp, 1937)

In the absence of knowledge of the larva, which was presumed to occur in wild ungulates, this species was distinguished primarily by the form of the rosteller hooks and by host occurrence (Ortlepp, 1937; Rausch, 1953) of the adult, which was known only from a lion (Felis leo) in South Africa. A critical appraisal of the limits of morphological variation in E. granulosus lessens the significance of the criteria used to separate E. felidis, including that of its occurrence in a member of the Felidae. In house cats, E. granulosus does not attain normal size or produce eggs (Lorincz, 1933; Drežančić and Wikerhauser, 1956). Although it has not been experimentally demonstrated that it will not do so in the

<table>
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<tr>
<th>Species</th>
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<th>No. of segments</th>
<th>Location of genital pore</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. cameroni</td>
<td>England (Vulpes vulpes)</td>
<td>5 to 7</td>
<td>4 or 5</td>
<td>Posterior to middle of segment in both mature and gravid segments*</td>
</tr>
<tr>
<td>E. lycaontis</td>
<td>Johannesburg Zool. Gardens (Lycaon pictus)</td>
<td>4 to 7 (av. 5)</td>
<td>Av. 5</td>
<td>Just posterior to middle of each segment</td>
</tr>
<tr>
<td>E. lycaontis</td>
<td>Johannesburg Zool. Gardens (Lycaon pictus)</td>
<td>4 to 6</td>
<td>Usually 5; sometimes more</td>
<td></td>
</tr>
<tr>
<td>E. intermedius</td>
<td>Almería, Spain (domestic dog)</td>
<td>3·3</td>
<td>4</td>
<td>Posterior to middle in mature and gravid segments (López-Neyra and Soler, 1943; fig. 3)</td>
</tr>
<tr>
<td>E. ortleppi</td>
<td>Vicinity of Pretoria, South Africa (domestic dog)</td>
<td>5 to 8·5</td>
<td>3</td>
<td>Middle in mature segments, posterior to middle in gravid segments</td>
</tr>
</tbody>
</table>

* Determined from examination

lion, Badinin (1947) (cited in Petrov and Lukashenko, 1962) identified cestodes from the intestine of a lion in the zoological garden of Samarkand as E. granulosus. Echinococcus adults were not found in four lions and 11 other wild felids in Kenya (Nelson and Rausch, 1963). The status of E. felidis remains uncertain.

Echinococcus cameroni Ortlepp, 1934

This species, which was found in the fox (Vulpes vulpes) in Great Britain, is based upon material previously identified as E. granulosus by Cameron (1926), from which it cannot be
distinguished on morphological grounds (Rausch, 1953) (Table III). The eggs in the terminal segment of some specimens indicated to Gemmell (1960) that *E. cameroni* might indeed be a valid species, since *E. granulosus* is not known to develop normally and to produce eggs in foxes (Matoff and Jantscheff, 1954; Gemmell, 1959). Sinclair (1956) found *Echinococcus* in six of 16 red foxes examined in Great Britain, mostly in Cardiganshire; the maximum number of cestodes in a single animal was small (evidently 64), as seems typical of *E. granulosus* in foxes, but it was not stated whether eggs were present. Cestodes from dogs in England were studied by Wright (1962), who was unable to distinguish them from *E. granulosus* on morphological grounds. The situation in Great Britain is complicated by the apparent occurrence of *E. multilocularis*, a typical and fatal case of alveolar hydatid disease having been described by Walshe (1954) in a patient who had never been out of the country. The evidence for recognizing *E. cameroni* as a valid species is insufficient, and we consider it to be a synonym of *E. granulosus*.

*Echinococcus patagonicus* Szidat, 1960

This cestode was obtained from a fox (*Dusicyon c. culpaeus*) in the Argentine. Except for the rather few testes (Table II), it lacks distinctive morphological characteristics.
Szidat (1960) noted that the absence of eggs might indicate occurrence in an unnatural host. *E. patagonicus* is readily differentiated from the South American *E. oligarthrus* but rather closely resembles *E. granulosus*. Additional information is required to clarify the status of this cestode.

*Species of Echinococcus Indistinguishable from E. granulosus*

Five species, *E. intermedius*, *E. longimanubrius*, *E. lycaontis*, *E. minimus* and *E. ortleppi*, appear to be indistinguishable from *E. granulosus* and are considered synonyms.

Ortlepp (1934) originally differentiated *E. lycaontis*, from the hunting dog (*Lycaon pictus*), by the size and number of the rostellar hooks and by the number of segments, and on these grounds it was retained as a distinct species by Rausch (1953). Table III shows that the presumed differences fall within the limits of normal morphological variation for *E. granulosus*. The accessory hooks observed on the rostellum of this cestode probably represent an anomalous condition comparable to the situation observed by Vogel (1957) when similar hooks were found on specimens of *E. granulosus* from dogs in Europe. We have seen supernumerary hooks on *E. granulosus* from domestic dogs in Kenya. Extra rows of hooklets have also been reported on the scolices of *Echinococcus* larvae (Bolkhovitinov, 1957, 1959) (cited in Petrov and Lukashenko, 1962). Specimens obtained from three hunting dogs (*Lycaon pictus*) in Kenya were all identified as *E. granulosus* (Nelson and Rausch, 1963).

*E. longimanubrius* Cameron, 1926 (from *Lycaon pictus*), and *E. minimus* Cameron, 1926 (from *Canis lupus*), were separated from *E. granulosus* solely by characteristics of the rostellar hooks. *E. intermedius* López-Neyra and Soler, 1943, was described from two specimens from a dog in Spain. The described differences of all three species fall within the limits of observed variations of *E. granulosus* (Table III).

Cestodes from dogs in the vicinity of Pretoria were identified by Ortlepp (1934) as *E. granulosus*. After comparing Ortlepp’s description with that by Leuckart, López-Neyra and Soler (1943) noted discrepancies which were considered to have specific value, and as a result they created a new species, *E. ortleppi*. Our data (Table III) do not substantiate this conclusion, and we accept Ortlepp’s original determination.

**SUMMARY**

1. The genus *Echinococcus* Rudolphi, 1801, is reviewed. The recorded measurements of all species are shown in tables, and their taxonomic status is discussed.

2. Three species of *Echinococcus* can be distinguished by morphological criteria and are considered valid: *E. granulosus*, *E. multilocularis* and *E. oligarthrus*. The status of *E. felidis* and *E. patagonicus* is uncertain, but both may be conspecific with *E. granulosus*. Six species are considered synonyms of *E. granulosus*: *E. cameroni*, *E. intermedius*, *E. longimanubrius*, *E. lycaontis*, *E. minimus* and *E. ortleppi*.

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