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A COMPARATIVE STUDY OF CATTLE-INFESTING *HAEMATOPINUS*, WITH REDESCRIPTION OF *H. QUADRIPERTUSUS* FAHRENHOLZ, 1916 (ANOPLURA: HAEMATOPINIDAE)*

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ABSTRACT: Cattle lice, *Haematopinus eurysternus* Denny and *H. quadripertusus* Fahrenholz, are two distinct species. *H. eurysternus* is compared with *H. quadripertusus* in various morphological traits, and *H. quadripertusus* is redescribed with a complete synonymy. A nomenclatorial problem and designation of lectotype for *H. eurysternus* is discussed, and a key to the species of cattle-infesting *Haematopinus* is also presented.

The sucking lice of *Haematopinus* are among the most devastating ectoparasites of domesticated animals (Matthysse, 1946). This genus includes *H. suis* (Linnaeus) on domestic swine, *H. asini* (Linnaeus) on horses and donkeys, *H. eurysternus* Denny and *H. quadripertusus* Fahrenholz on cattle, and *H. tuberculatus* (Burmeister) on the Asian buffalo and occasionally on cattle. Other species are found on various wild ungulates, swine, antelope, African buffalo, zebra, deer, and occasionally on camels throughout the world (Ferris, 1951; Stimie and van der Merwe, 1968).

H. eurysternus is generally considered to be the most economically important species of cattle lice. This louse has been recorded from many parts of the world. *H. tuberculatus* is principally a parasite of the water or Indian buffalo (*Bubalus bubalis*) in India, Pakistan, China, Southeast Asia, Philippines, Guam, Africa, Egypt, Madagascar, Australia, and other parts of the world where this buffalo has been domesticated. Apparently, *H. tuberculatus* has been fully established on cattle in Australia (Roberts, 1938, 1950, 1953). *H. quadripertusus*, the tail-switch louse, has been unconvincingly synonymized with *H. eurysternus* (Ferris, 1933, 1951; Stimie and van der Merwe, 1968). Following Ferris' work most veterinary parasitology textbooks which have recently been published do not mention *H. quadripertusus* (e.g., Lapage, 1968). Soulsby (1968) recorded it as a parasite of cattle in only Queensland, New Guinea, and the Solomon Islands, and further correctly stated that it was previously thought to be *H. eurysternus*. Benbrook (1958) lists *H. quadripertusus* as cattle tail louse distinct from *H. eurysternus*.

H. quadripertusus and *H. tuberculatus* occur on the tails of cattle in both the Eastern and Western Hemisphere (Van Volkenburg, 1936; Becklund, 1964), although *H. tuberculatus* is commonly found on the general body surface of the buffalo (Chaudhuri and Kumar, 1961). This species was first recorded from Florida in the United States (Bruce, 1947; Creighton and Dennis, 1947). Becklund (1964) recorded *H. quadripertusus* as a tail louse in Texas, Alabama, Florida, and Puerto Rico. Ferris (1933, 1951) maintained that *H. quadripertusus* is a large form of *H. eurysternus*. Stimie and van der Merwe (1968) also followed the general conclusion made by Ferris (1951). However, the name *H. quadripertusus* has been available and also recognized as a distinct species by several authors (Roberts, 1950; Stojanovich and Pratt, 1965; James and Harwood, 1969). Stojanovich and Pratt (1965) separated *H. quadripertusus* from *H. eurysternus* by taxonomic characters found in the thoracic sternal plate and male genitalia.

The morphological differences between *H. eurysternus* and *H. quadripertusus* came to our attention independently, while the senior author (WPM) was involved in a joint effort to

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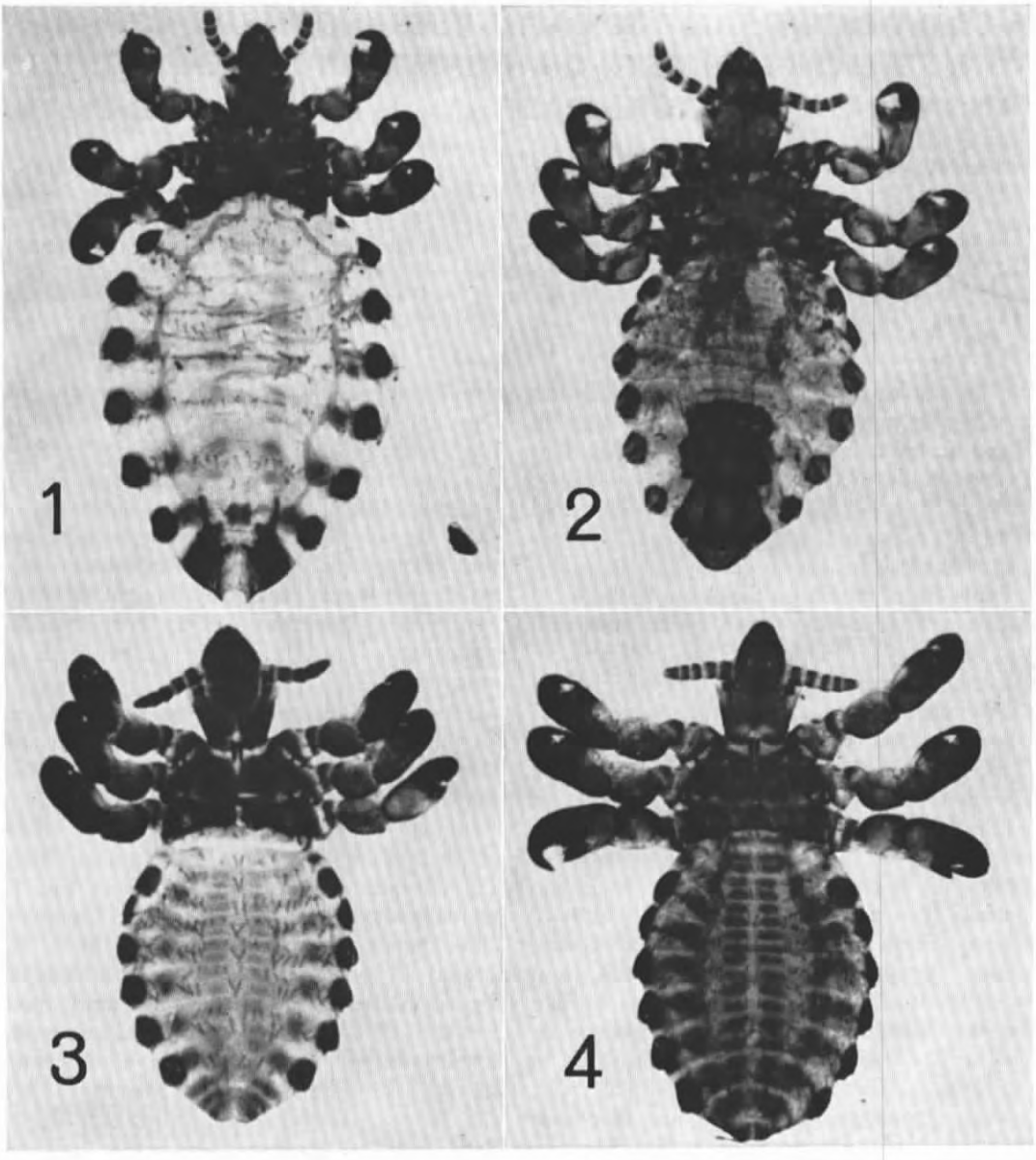
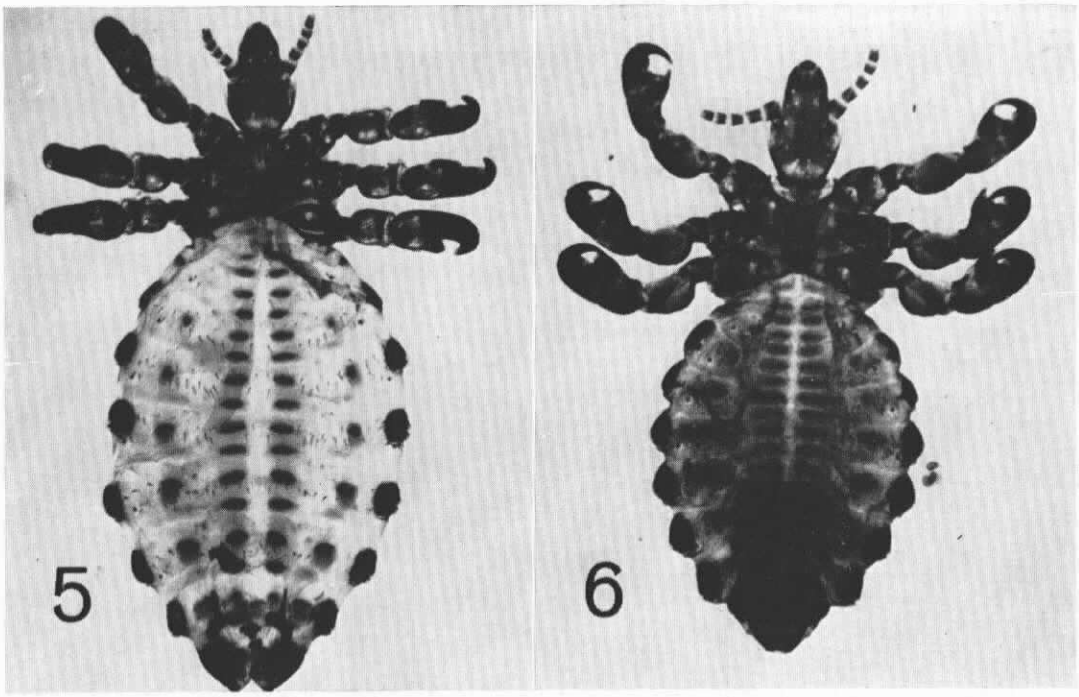


produce a comprehensive textbook on veterinary parasitology and the junior author (KCK) was preparing a monograph on Anoplura. We have also found considerable infraspecific variations as well as sexual dimorphism in several morphological characters for these taxa. Thus, this study was undertaken to provide comparative data on infra- and interspecific variations of *H. eurysternus* and *H. quadripertusus*. With this information accurate identification of cattle lice can be made by scientists in veterinary medicine and animal sciences.

This paper compares *H. eurysternus* and *H. quadripertusus* in various morphological traits and redescribes *H. quadripertusus*. A nomenclatorial problem and designation of lectotype for *H. eurysternus* is discussed, and a key to the species of cattle-infesting *Haematopinus* is also presented.



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FIGURES 1–6. Cattle lice, *Haematopinus* spp. **1–3**. *H. eurysternus* Denny; 1. Female. 2. Male. Nymph 3. **4–6**. *H. quadripertusus* Fahrenholz; 4. Nymph 3. 5. Female. 6. Male.

MATERIALS AND METHODS

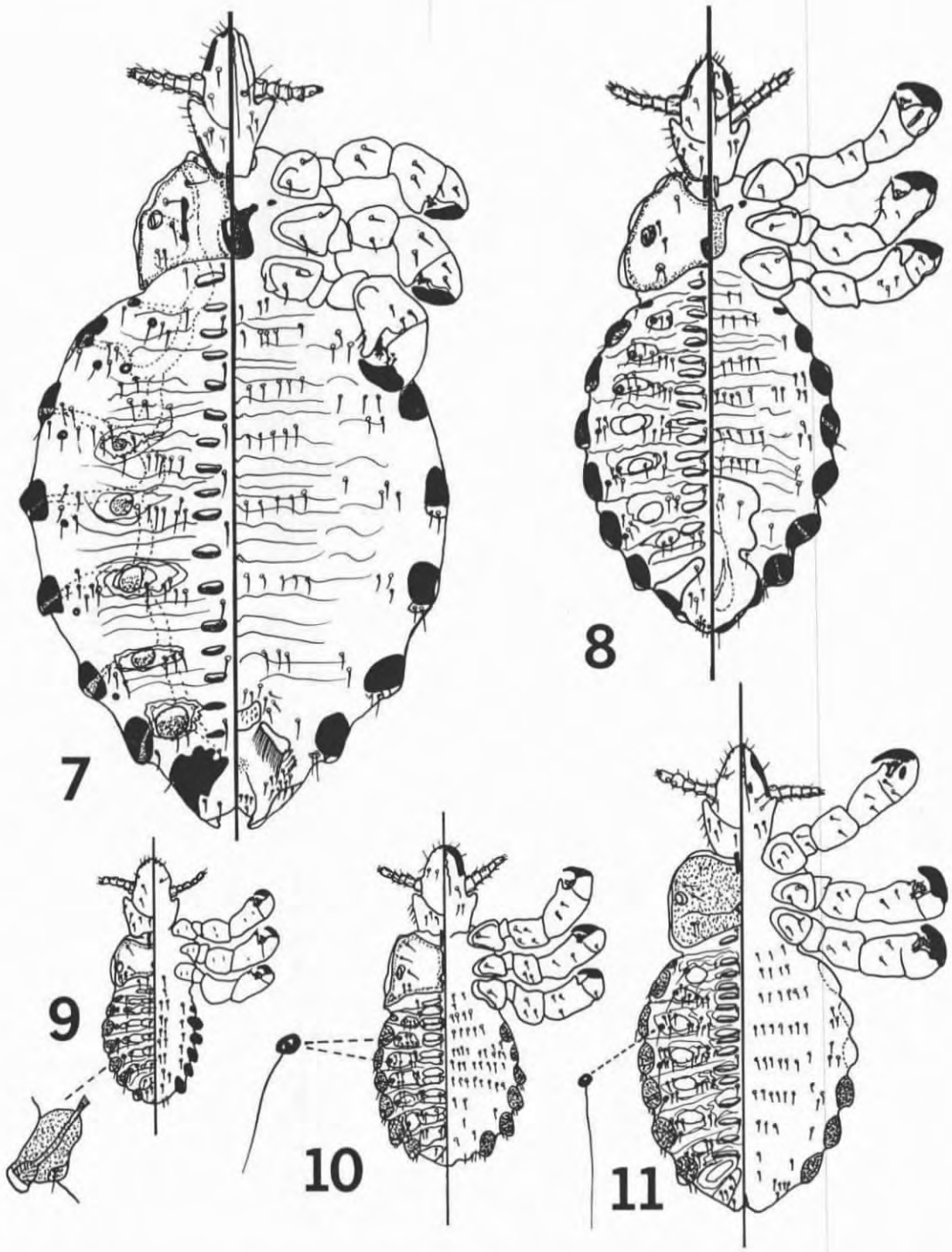
Specimens of *Haematopinus eurysternus* were collected from two Hereford cattle purchased from an abattoir in Albuquerque, New Mexico. Both cattle were parasitized with literally hundreds of thousands of lice. The individual lice examined were collected from the least-haired parts of the body (such as the caudal folds, the lips of the vulva, and the escutcheon) to make the task of separating the lice from each other and from the hairs of the host less arduous. The specimens of *H. quadripertusus* studied were collected and preserved in alcohol by members of the field force of the Animal and Plant Health Inspection Service, U. S. Department of Agriculture, in Puerto Rico. These were mailed to the senior author in 2 separate collections by Dr. Oren L. Kelsey, Veterinarian in Charge at San Juan, with the approval and cooperation of Dr. J. L. Wilbur, Jr., Assistant Director, Veterinary Services, Animal and Plant Health Inspection Service, Hyattsville, Maryland.

Extensive collections of *H. eurysternus* and *H. quadripertusus* from various institutions have also been studied: University of California, Berkeley (UCB); United States National Museum, Washington (USNM); The Frost Entomological Museum, The Pennsylvania State University (FEM); British Museum, London, England (BM); University of Heidelberg, Germany (UH); Royal Museum of Central Africa, Tervuren, Belgium (MRAC); Zoological Museum at Berlin, Germany (ZMB); and others.

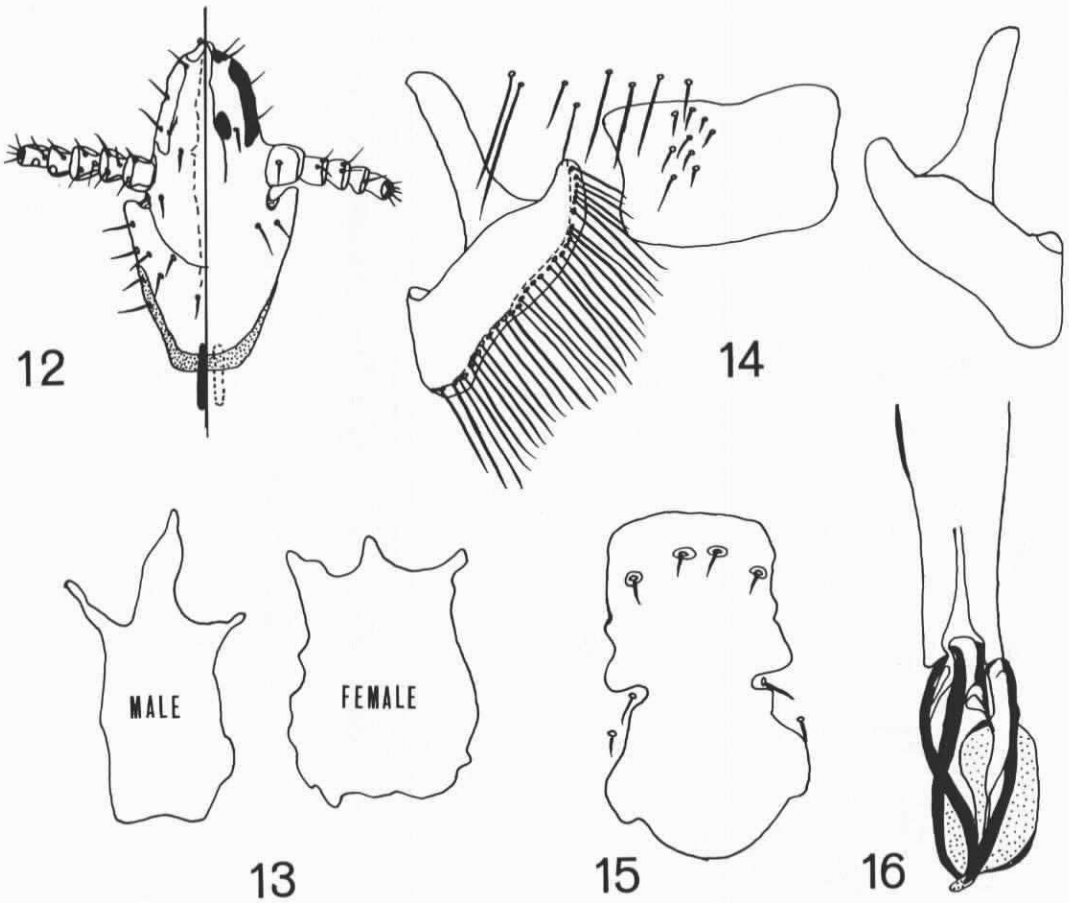
Since there are so many incorrect identifications and citations in the literature, complete lists of synonyms and taxonomic citations are given for both species, *H. eurysternus* and *H. quadripertusus*, in view of the proposed validation and resurrection of the name *H. quadripertusus*. The type data, diagnosis, distribution and host data, and records of the specimens examined are given for each species, along with various illustrations.

We generally followed the procedure and technique described by Kim, Brown, and Cook (1966) for preparation and measurement of specimens. The morphological terminology of Kim (1966) and Weisser and Kim (1972) is followed in this paper. Seven taxonomic characters were measured for female, and 8 characters measured for male: total body length (TBL), head length (HL), head width (HW), thoracic sternal plate length (TSPL) thoracic sternal plate width (TSPW), width between gonopods (WBG), gonopod length (GL) (left side), basal apodeme length (BA), paramere length (PL), and subgenital plate length (SGPL).

Samples of four populations of *H. eurysternus* and of five populations of *H. quadripertusus* were examined and compared. Means and standard



FIGURES 7–11. *Haematopinus quadripertusus* Fahrenholz (left legs removed). **7**. Female. **8**. Male. **9**. Nymph 1, 7th abdominal spiracle. **10**. Nymph 2. **11**. Nymph 3.



FIGURES 12–16. *Haematopinus quadripertusus* Fahrenholz. **12**. Female head. **13**. Thoracic sternal plate. **14**. Female genitalia. **15**. Male subgenital plate. **16**. Male genitalia.

deviations were computed for each population and pooled for each species.

H. eurysternus:

New Mexico population (NM)—ex neck of Hereford cow, Albuquerque, N. M., 31 July 1973, Coll.—W. P. Meleney.

Oregon population (OR)—ex cattle, Corvallis, Oregon, 1958, G. W. Eddy; ex Hereford steer, Benton Co., Oregon, 5 May 1958.

Wyoming population (WY)—ex Holstein cows, Evanston, Wyoming.

Australian population (AU)—ex cattle, Queensland, Australia, 1948, Coll.—F. H. S. Roberts.

H. quadripertusus:

Puerto Rico population (PR)—ex tails of beef and dairy cows, San Juan, Puerto Rico, 12 May 1969, O. Kelsey.

Florida population (FL)—ex cattle, Florida, 1947, Survey.

Taiwan population (TA)—ex domestic cattle, Hsin Chu Sheh, Taiwan, 3 August 1961, PF-12695.

Cambodia population (CA)—Village Damflect, Cambodia, 14 June 1952, C. Wharton.

Madagascar population (MA)—ex eyelids and vulva of cow, Kianjasoa, Madagascar, 9 June 1966, Coll.—Uilenberg.

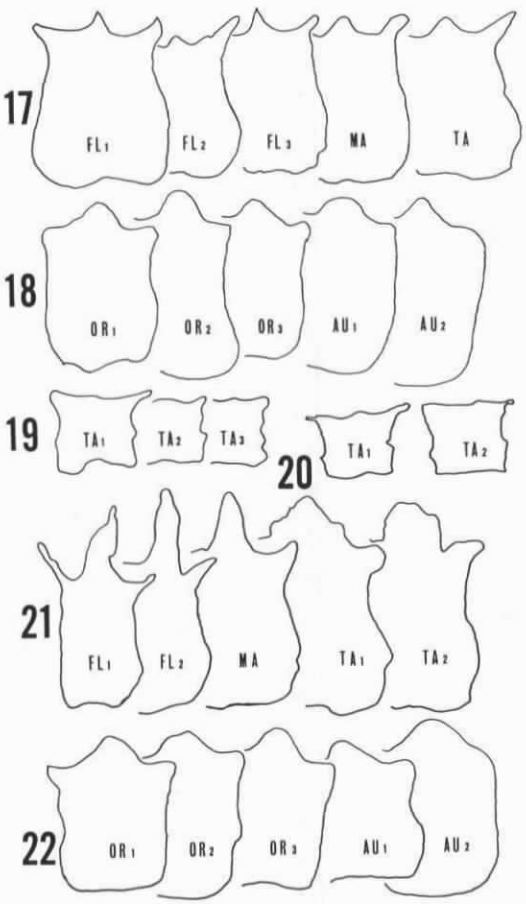
H. tuberculatus (Burmeister)

Taiwan population (TA)—ex cattle, PuLi, Nan Ton, Hsien, Taiwan, Sept. 1959.

Haematopinus eurysternus Denny (Short-nosed cattle louse)

(Figs. 1–3, 18, 22, 24, 27, 30, 33)

Haematopinus eurysternus Denny, 1842: 29–30, pl. 25, fig. 5 (type host: "The Ox"); Gurlt 1843: 10; Piaget 1880: 648, pl. 53, fig. 1; Osborn, 1891: 13, fig. 6; Osborn 1896: 172–5; Dalla Torre 1908: 11; Ferris 1916: 144; Lamson 1917: 446; Freund 1927: 43, fig. 2; Ewing 1929: 137; Kohn 1929: 60; Freund 1935: 10–11, figs. 32–7; Blagoveschtchensky 1937: 43; Maltbaek 1937: 7–8; Jancke 1938: 54, fig. 4; Craufurd-Benson 1941: 336–58; Matthysse 1944:



FIGURES 17–22. Thoracic sternal plates. 17–19. Females. **17**. *Haematopinus quadripertusus* Fahrenholz. **18**. *H. eurysternus* Denny. **19**. *H. tuberculatus* (Burmeister). 20–22. Males. **20**. *H. tuberculatus* (Burmeister). **21**. *H. quadripertusus* Fahrenholz. **22**. *H. eurysternus* Denny. FL = Florida population; MA = Madagascar population; TA = Taiwan population; OR = Oregon population; AU = Australian population.

436–42; Seguy 1944: 449–50; Kloet and Hincks 1945: 27; Eichler 1946: 105; Conci 1946: 7; Matthysse 1946: 3–61; Webb 1946: 91–5, figs. 189–204; Brinck 1948: 129–52; Webb 1948: 583; Hopkins 1949: 527; Roberts 1950: 136–38; Cooreman 1952: 2; Peterson et al. 1953: 373–77; Britz 1955: 153–4, figs. 5–7; Scanlon 1960: 121; Shemanchuk et al. 1960: 158–61; Costa Lima 1961: 15, fig. 181; Markevich 1961: 111; Scharff 1962: 684–8; Kéler 1963: 7; Blagoveschtchensky 1964: 327; Piotrowski 1964: 594–602; Smetana 1965: 34–35, fig. 1; Spencer 1966: 24; Wegner 1966: 8; Stimie and v.d. Merwe 1968: 190–4, figs. 3, 4; Piotrowski 1967: 643–51; Wegner 1967: 653–7; Voicu 1969: 26; Wegner 1972: 29–30, figs. 33–7.

Haematopinus eurysternus (*partim*): Ferris 1933: 448–53, figs. 263, 264 C, G–J; Ferris 1951: 88–9, figs. 39, 40; Blagoveschtchensky 1960: 52–4, figs. 34–8; Calaby 1970: 381, 386.

(Non) *Pediculus eurysternus* Nitzsch, 1818: 305 (*nomen nudum*).

(Non) *Haematopinus eurysternus* Nitzsch: Stephens 1829: 239; Burmeister 1838: 14; Giebel 1874: 41–2, pl. 2, fig. 8.

Haematopinus brevipes Fiedler and Stampa, 1956: 63–5, figs. 23–6 (descr. female) (type host: *Taurotragus oryx oryx*); Fiedler and Stampa 1958: 182, fig. 23 (descr. male).

Nitzsch (1818) named a louse from "Bovis tauri" as *Pediculus eurysternus* without description and illustration. The type specimens were examined and clearly recognized as *Solenopotes capillatus* Enderlein (Kim and Weisser, 1973). Denny (1842) was the first author who used erroneously the name *Haematopinus eurysternus* for the short-nosed cattle louse which has subsequently been described as *S. capillatus*. The lectotype has been designated from the Denny Collection of the British Museum, London, England. A proposal to preserve the well-known names *Haematopinus eurysternus* for the short-nosed cattle louse and *Solenopotes capillatus* Enderlein, 1904, for the little blue cattle louse for stability of the nomenclature has been published by the International Committee for Zoological Nomenclature (Kim and Weisser, 1973).

Type data: Lectotype female, "*Haematopinus eurysternus* Denny, 1842, Britain, '1852–98,' Denny Collection," and paralectotype female, "Britain, '1852–98,' Denny Collection." They are deposited in the Denny Collection of the British Museum (Nat. Hist.), London, England.

Diagnosis (Figs. 1–3): Smallest cattle-infesting *Haematopinus*. Total body length: female 2.88 mm ($\bar{x}$) (range = 2.33 to 3.18 mm), male 2.33 mm ($\bar{x}$) (range = 1.99 to 2.7 mm). *H. eurysternus* is separable from *H. quadripertusus* by the smaller size, much thinner abdominal tracheal trunks, and the thoracic sternal plate with median projection blunt and rounded (Figs. 18, 22). Female of *H. eurysternus* has rather short and compact gonopods (Fig. 24) and pointed anteromedial processes of the 9th tergite (dorsal genital plate) (Fig. 27). Male of this species has 5 or 6 setae on the anterior part of the subgenital plate (Fig. 33). *H. eurysternus* is further distinguished from *H. tuberculatus* by the smaller size and only 2 marginal setae posterior to each paratergal plate (Fig. 30).

Distribution and host: The primary host of this species is domestic cattle (= *Bos taurus domesticus*) which has likely originated in the Palearctic region. As cattle were introduced into different parts of the world, *H. eurysternus* has also spread worldwide. This species is now commonly found on domestic cattle in cold and temperate zones. This species was also collected once from an eland (*Taurotragus o. oryx*), Transvaal, South Africa, but this incidence may have been a contamination. Reliable records of *H. eurysternus* have been available from North America, Europe, Russia, Turkey, Australia, and South Africa.

Remarks

As Stimie and van der Merwe (1968) pointed out, extensive infraspecific variations were observed in the thoracic sternal plate (Figs. 18, 22), subgenital plate (Fig. 33), ventral postantennal head setae (VPoLHS), number of abdominal sclerotic plates, total body length (TBL), length of basal apodeme (BA), and paramere length (PL) (Tables I, II). However, these variations are distinctly delimited and *H. eurysternus* is easily separable from *H. quadripertusus*.

Specimens examined: Ex cow or ox of *Bos taurus*, USA: CALIFORNIA: 1 male and 1 female (USNM); MINNESOTA: Zumbrota, 1 male and 1 nymph (C4645) (FEM); MONTANA: 1 female (USNM); NEW JERSEY: New Brunswick, 1 male and 1 female (Bish. No. ?/202) (UCB); 2 males, 2 females, and 3 nymphs (USNM); NEW MEXICO: 30 females, 10 males, 7 nymphs, ex neck of Hereford cow, Albuquerque, 31 July 1973, W. P. Meleney (FEM); NEW YORK: 3 males, ex calf (USNM); NORTH DAKOTA: 1 female, 5 males, and 12 nymphs (USNM); 1 male and 3 nymphs (USNM); OREGON: Corvallis, 1958, Eddy coll., 40 males and 40 females (compared with lectotype) (FEM); PENNSYLVANIA: McKean Co., 28 April 1970, Adams coll., 2 females (FEM); TEXAS: 8 females and 8 males, ex Hereford steer (USNM); 3 females (USNM); WYOMING: 4 females and 5 males, from Holstein cow (USNM). BRITAIN: 2 females, 1852–98, Denny Coll. (lectotype and paralectotype; BM); 1 male, Rev. Canan Normani's coll., R. Kirkpatrick (No. 1915–197) (BM). GERMANY: Schönwalde, 27 Feb. 1948, 6 females, 3 males, and 1 nymph, from "Rind," Herold coll. (UH); Heidelberg, 19 March 1968, from imported bull from Hungary, Heindel coll., a long series (UH); Leutershausen, 12 Jan. 1968, from young bull, Heindel coll., a long series (UH). AUSTRALIA: Queensland, 1948, Roberts coll., 2 females and 1 male (UH). SOUTH AFRICA: Zululand, 27 July 1922, Carson coll., 2 females and 1 male (ox: 4024) (Nagana Res. Lab.); (BM); ex *Taurotragus o. oryx*, eland. SOUTH AFRICA: Mopane, Transvaal, 31 Aug. 1953, v.d. Merwe coll. (paratype of *H. brevipes*), 1 female (BM).

Haematopinus quadripertusus Fahrenholz (Cattle-tail louse)

(Figs. 4–17, 21, 23, 26, 29, 32)

Haematopinus quadripertusus Fahrenholz, 1916a: 19–21, figs. 15–7 (type host: "Rinder" from Cameroon); Fahrenholz 1916b: 91; Bruce 1947: 590; Creighton and Dennis 1947: 911; 1947: 911; Roberts 1950: 136–138; Benoit 1964: 154; Stojanovich and Pratt 1965: 5; Capriles and Gaud 1971: 516.

Haematopinus eurysternus (*partim*); Neumann 1909: 498–500; Bedford 1926: 737; Ferris 1933: 448–453, figs. 264A, B, D–F; Roberts 1938: 55; Wolcott 1948: 102; Ferris 1951: 88–89; Benoit 1959: 114–115; Wenzel and Johnson 1966: 274; Segal et al. 1968: 421; Stimie and v.d. Merwe 1968: 190–194.

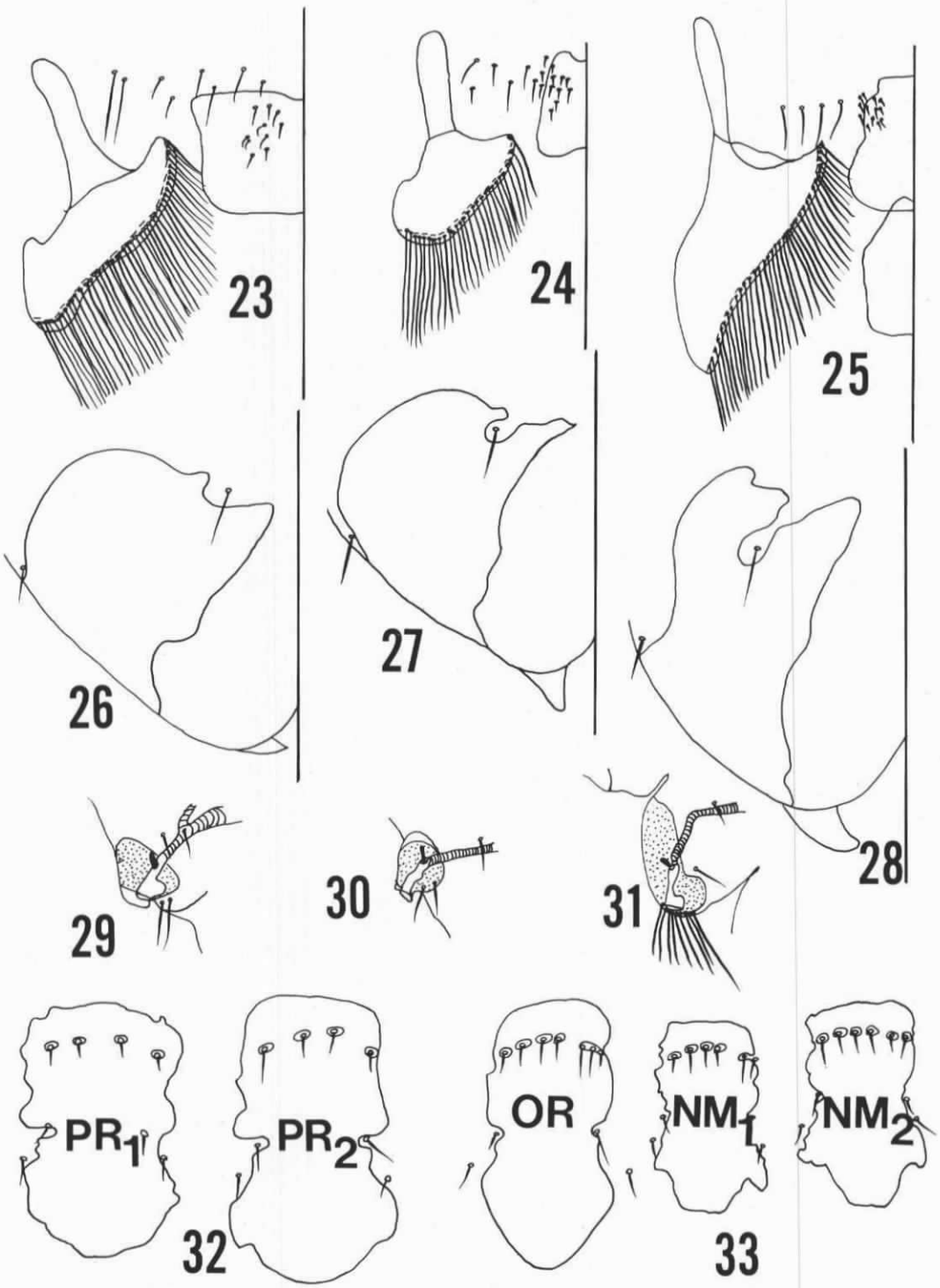
Haematopinus parviprocursus Fahrenholz, 1916a: 21–22 (type host: "Rinderart" Southwest Africa): Fahrenholz 1916b: 91.

Haematopinus palpebrae Gretillat, 1957: 167–172, figs. 1–3 (type host: *Bos indicus*, the zebu from Madagascar) (new synonymy).

Type data: This species was originally described by Fahrenholz (1916a) on the basis of about 100 specimens of males and nymphs which were taken from cattle (Banjo, Cameroon). No female was available. They were supposed to be deposited in the collection of the Zoological Museum at Berlin, but no type specimen was located at the Museum (Ludwig, 1973, pers. comm.). The type specimen of *H. palpebrae* is deposited in the collection of the Laboratoire central de l'Elevage et des Industries Animales a Tananarive, Madagascar.

Diagnosis: *H. quadripertusus* is a large louse, differing from *H. eurysternus* and *H. tuberculatus* by many characters. This species is larger than *H. eurysternus* but usually smaller than *H. tuberculatus*. The median and anterolateral processes of the thoracic sternal plate are prolonged and pointed (Figs. 13, 17, 21). The tracheal trunks of the abdomen are extremely thick. The female has more elongated gonopods, a broader and shorter median genital plate (Figs. 14, 23), and blunt anteromedial processes of the 9th tergite (Fig. 26). The subgenital plate of the male possesses 3 or 4 small setae anteriorly (Figs. 15, 32).

Description: FEMALE (Figs. 6, 7): Total body length (TBL) 3.99 mm ($\bar{x}$), range 3.42 to 4.75 mm. *Head* small, slender, with distinct ocular points; head length 0.86 mm ($\bar{x}$) and head width 0.55 mm ($\bar{x}$); clypeus distinctly sclerotized; occiput and ocular sinuses strongly sclerotized; chaetotaxy typically haematopinoid, as in Figure 12; dorsal principal head setae (DPHS) short; 4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marginal head setae (MHS) present; hindhead ventrally with 1 ventral principal head seta (VPHS) and 1 postantennal lateral head seta (VPoLHS) (the number of these setae varies from 1 to 3). Antennae relatively long, 5-segmented; segments 4 and 5 each with a dorsal sensorium. *Thorax* much wider than head, heavily pigmented, with distinct notal pit and sternal plate (Figs. 13, 17); sternal plate with anterolateral processes prolonged and acute and median process long, sometimes acute; metanotal projection hardly developed; dorsum with 1 prothoracic seta, 1 mesothoracic seta located anterior to the spiracle, 1 principal thoracic seta short, and 2 metathoracic setae; no ventral setae present. *Legs* as in other members of *Haematopinus*; euplantula distinct; coxae III with small posterior tubercle. *Abdomen* membranous, leathery and wrinkled, with distinct paratergites and spiracles on segments 3–8; segment 2 with a small paratergite and one paratergal seta; segments 3–8, each paratergite with a pair of paratergal setae (Fig. 29); dorsally with about 17 pairs of small median sclerotic plates and about 6 or 7 lateral sclerotic plates; 9th tergite (dorsal genital plate) not connected medially, with anteromedial process blunt (Fig. 26); 9 dorsal central abdominal setae (DCAS); segments 4–6 each with 5 or more intermediate abdominal setae (DImAS); segments 1–3 each with a single DImAS; segments 3 and 4 each with 3 or 4 dorsal lateral abdominal setae (DLAS), one of which has a heavily sclerotized socket base; ventrally with 7 transverse rows of small ventral abdominal setae (VAS); segments 2–8 each with 6–10 median abdominal setae (VMdAS), and 1–3 VMLAS and 3 or 4 VLAS on each side; terminal segment with a pair of apical lobes. *Genitalia* (Figs. 14, 23): Gonopods long, narrow, with diverging inner margins, long posterior setae on the margin and with strong anterior apodeme; median genital plate subtrapezoid or subrectangular, wider than long, with minute setae; anal area with 2 or more minute setae; a patch of about 14 long setae present posterior to the gonopods on each side.

MALE (Figs. 5, 8): Total body length 3.19 mm

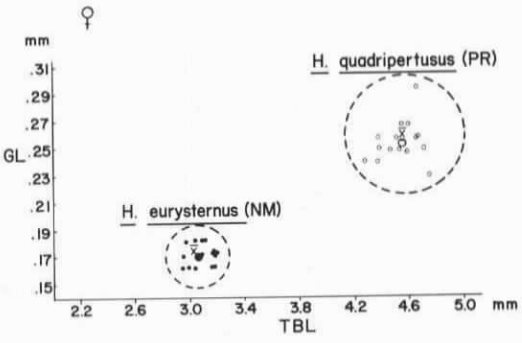

FIGURE 34. Scatter diagram showing discrimination of *Haematopinus eurysternus* Denny and *H. quadripertusus* Fahrenholz (females). GL = gonopod length, TBL = total body length, NM = New Mexico population, and PR = Puerto Rico population.

($\bar{x}$) range 3.04 to 3.52 mm. Head, thorax, legs, and abdomen same as in female with usual sexual dimorphism, unless mentioned otherwise. Head length 0.77 mm ($\bar{x}$) and head width 0.51 mm ($\bar{x}$). *Abdomen* smaller, with lateral sclerotic plates large and distinct; venter with slightly sclerotized median plates; subgenital plate with 3 or 4 anterior setae. Genitalia similar to those in most other members of the bovid-infesting *Haematopinus* (Figs. 15, 16, 32); basal apodeme weakly sclerotized anteriorly; parameres posteriorly fused into a sharp point, surrounding endotheca and aedeagus.

NYMPH 3 (Figs. 4, 11): Total body length 2.74 mm ($\bar{x}$) ($n = 7$). Head, thorax, legs, and abdomen similar to those of adults, except for the following characters. The entire notum heavily sclerotized and fused. *Abdomen* with 16 median, 7 lateral, and 2 terminal sclerotic plates on each side; dorsal membrane with numerous furrows and wrinkles; dorsum with 9 DCAS, 2–6 DImAS (with sclerotized socket base); 6 paratergites and spiracles present on segments 3–8, each with a pair of paratergal setae; venter with 9 transverse

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FIGURES 23–25. Female genitalia (right side not shown). **23**. *H. quadripertusus* Fahrenholz (Puerto Rico population). **24**. *H. eurysternus* Denny (New Mexico population). **25**. *H. tuberculatus* (Burmeister) (Taiwan population).

FIGURES 26–28. Female ninth abdominal tergites (dorsal genital plate) (left side only). **26**. *H. quadripertusus* Fahrenholz (Puerto Rico population). **27**. *H. eurysternus* Denny (New Mexico population). **28**. *H. tuberculatus* (Burmeister) (Taiwan population).

FIGURES 29–31. Female seventh abdominal spiracles. **29**. *H. quadripertusus* Fahrenholz (Puerto Rico population). **30**. *H. eurysternus* Denny (New Mexico population). **31**. *H. tuberculatus* (Burmeister) (Taiwan population).

FIGURES 32–33. Male subgenital plate. **32**. *H. quadripertusus* Fahrenholz (Puerto Rico population). **33**. *H. eurysternus* Denny (Oregon and New Mexico populations).

rows of setae, 3–7 VMdAS on segments 1–7 and 1–3 VLAS on each side; anal segment with 5 short DLAS; 9th tergite with 3 or 4 setae.

NYMPH 2 (Fig. 10): Total body length 2.36 mm ($\bar{x}$) ($n = 10$). Smaller than nymph 3 but very similar in general appearance.

NYMPH 1 (Fig. 9): Total body length 1.47 mm ($\bar{x}$) ($n = 12$). Generally similar to nymph 2 with reduction in chaetotaxy and fusion of sclerotic plates. *Head* with only one VPaHS and no VPHS and VLMHS. *Thorax* with no mesothoracic seta (DMsS). *Abdomen* without DImAS; 7 DMLAS and 6 DLAS present on segments 2–8; venter with 9 rows of ventral abdominal setae, 2–4 VMdAS and 6 VLAS; 6 paratergites and spiracles present on segments 3–8, each paratergite with only a single posterior seta (Fig. 29).

Distribution and host: *Bos indicus*, the zebu or humped cattle, must be considered as the type host of *H. quadripertusus*. Hybrids of *Bos indicus* and *Bos taurus* (both domestic) are also qualified hosts. One record of an apparently atypical host, a Hereford steer, comes from Texas. *Bos indicus*, which may have originated from the Oriental region, is now under domestication in many parts of the world, mainly in subtropical and tropical zones. Valid records of this species have been made from southern United States; Florida, Louisiana, Texas; Panama Canal Zone; Puerto Rico; Costa Rica; Mexico; Venezuela; Africa (south of the Sahara); Madagascar; India; Ceylon, Malaya; Taiwan; Seychelles Islands; Australia.

Remarks

There are considerable infraspecific variations in several taxonomic characters; the thoracic sternal plate (Figs. 17, 21), subgenital plate (Fig. 32), VPoLHS, median sclerotic plates, DImAS, DMLAS, DLAS, 9th tergite (dorsal genital plate) (Fig. 26) and others (Tables 1, II). However, these variations are clearly delimited for most of the characters, and *H. quadripertusus* is definitely different from *H. eurysternus* in many taxonomic characters (Tables I, II, Figs. 34, 35).

Specimens examined: Ex domestic cattle or *Bos taurus*, USA: FLORIDA: Kissimmee, 20 Jan. 1947, A. L. Smith, 2 specimens (Bish. No. 24321; British museum No. 1971-189) (BM); 18 lots with 46 females, 26 males, 13 nymphs, and eggs from head and tail; Bradley Junction, 15 Oct. 1946, W. G. Bruce, 2 males, 2 females, and 3 nymphs (Bish. 24921, 24943; lot 47-1776) (FEM); Bartow, 14 Jan. 1947, C. C. Kipper, 1 male, 1 female, and 1 nymph (Bish. 24325) from range steer (FEM); 1947 survey, 6 females and 2 males (FEM); LOUISIANA: 4 females, 2 females, 1 male, and 2 nymphs, 1947 survey (FEM); TEXAS: 2 females, from cow's switch (USNM); 7 females and 1 nymph, from Hereford (switch). BRAZIL: parahybe do Sol, Rio de Janeiro, short series (FLW 25) (BM). PUERTO RICO: 6 females from cow's tail (USNM); 1 female from cow's tail (USNM); 2 males and 17 nymphs from eyelid (USNM). LESSER ANTILLES: Barbados Island, July 1933, 2 specimens (No. 354) (BM). MEXICO: 5 females and 4 males from brush of cow. CANAL ZONE, PANAMA: 1921, Dunn coll., 1 female and 1 male (UCB). PUERTO RICO: 30 females, 10 males, 7 nymphs, ex tails of beef and dairy cows, San Juan, O. Kelsey. GAMBIA: Bathurst, 1908, Hood coll., 2 females (UCB). KENYA: South Side Mt. Elgon, 14 Jan. 1958, Barnett coll., 4 specimens from calves (BM). MALI: Nov. 1970, Mol. coll., a series from Bovin (ZMB). UGANDA: Kampala, 5 Oct. 1937, Hopkins coll., 3 females and 1 male (No. 1958-313) (BM); Kampala, 25 Oct. 1937, Hopkins coll., 8 specimens; 13 April 1926, Pillers coll., 1 specimen (BM). MADAGASCAR: Sakay, 8 Nov. 1962, Arnaud coll., from eyes and tail-switch, 22 specimens (No. 1963-634) (BM); 2 females from tail (USNM); on vulva, Kianjasoa, 9 June 1966, Uilenberg coll., 13 males, 5 females, and 30 nymphs (FEM). CENTRAL AFRICAN REPUBLIC: Birao, 11 Feb. 1970, Uilenberg, a series of males, females, and nymphs from Bovin (FEM); Lac Mamoun, 15 Feb. 1970, Uilenberg coll., a series from Bovin (FEM); Birao, 17 Dec. 1969, Thal coll., a series from Bovin; Bewiti, 1969, Uilenberg coll., a series from Bovin (FEM). CAMEROUN: 5 males from *Bos* sp. (No. 2408–2410) (FEM). ZAIRE: Maniema, Kasango, 2 females, Sept. 1954, 2 females (MRAC); Sakania, Katanga, 16 July 1932, 2 females (MRAC); Elisabethville (= Lubumbashi), 1930, 1 female (MRAC); Stanleyville (= Kisangani), 1932, 1 male and 1 nymph (MRAC). RWANDA: Nyakotane, May 1931, 2 males (MRAC); and other numerous slides from Venezuela, Puerto Rico, Costa Rica, southern USA, Nganda, and Australia. AUSTRALIA: Mackay, Queensland, July 1893, 2 specimens from tail (BM); 2 females (USNM). CEYLON: 6 specimens (BM). SEYCHELLES ISLAND: Barbaron, 4 May 1906, Dupoit coll., 2 specimens from Bullocks (No. 1911-147) (BM). MALAYA: Puchong, 20 Aug. 1965, Griffith coll., 1 specimen (No. 1965-639) (BM); Trengganu, 1968, A. Mustebba, 1 male and 1 female (No. 1968-292) (BM). CAMBODIA: Village Damflect, 14 June 1952, C. Wharton, 1 female (RTB-15383) (FEM). TAIWAN: Hua-Shan, Taipei, 1 April 1961, a series of males, females, and nymphs (No. 10454) (FEM); Tai-shan, Taipei Hsien, 30 April 1961,

TABLE I. *Means and standard deviations of seven taxonomic characters for* Haematopinus eurysternus *Denny and* H. quadripertusus *Fahrenholz (females); NM = New Mexico, OR = Oregon, WY = Wyoming, AU = Australia, PR = Puerto Rico, FL = Florida, TA = Taiwan, CA = Cambodia. All units in mm.*

Species	*H. eurysternus*					*H. quadripertusus*				
Populations Sample size	NM 15	OR 6	WY 1	AU 3	Total 25	PR 15	FL 6	TA 2	CA 1	Total 24
TBL	3.09	2.87	3.04	2.55	2.88 ± 0.21	4.54	4.11	3.89	3.42	3.99 ± 0.40
HL	0.63	0.63	0.53	0.55	0.59 ± 0.05	0.89	0.85	0.86	0.84	0.86 ± 0.02
HW	0.44	0.44	0.42	0.45	0.44 ± 0.01	0.54	0.54	0.57	0.55	0.55 ± 0.01
TSPL	0.30	0.29	*—	*—	0.30 ± 0.01	0.31	0.30	0.31	0.33	0.31 ± 0.01
TSPW	0.23	0.21	*—	*—	0.22 ± 0.01	0.27	0.24	0.27	0.26	0.26 ± 0.01
WBG	0.20	0.19	0.21	0.18	0.20 ± 0.01	0.26	0.25	0.22	0.20	0.23 ± 0.02
GL	0.17	0.17	0.17	0.17	0.17 ± 0.00	0.25	0.24	0.23	0.23	0.24 ± 0.01

* Specimens were overcleared.

a series of males and females (No. 14008) (FEM); Hsin chu Sheh, 3 Aug. 1961, 2 males and 2 females (PF 126945) (FEM); ex zebu or *Bos indicus*. MADAGASCAR: Tananarive-Baulieve, 1 March 1967, Lapier coll., long series of males, females, and nymphs (FEM). ZAIRE: Maniema, Kasango, 29 Sept. 1959, several females and males from zebu type *Bos taurus* (MRAC).

DIFFERENCE BETWEEN *HAEMATOPINUS EURYSTERNUS* AND *H. QUADRIPERTUSUS*

Since *Haematopinus quadripertusus* was originally described by Fahrenholz (1916a), this species has not been recognized by Ferris (1933, 1951) and subsequently by other workers. However, few field scientists have recognized the difference between *H. quadripertusus* and *H. eurysternus* on the basis of their microhabitats and behavior in addition to rather variable morphological characters (Bruce, 1947; Creighton and Dennis, 1947; Roberts, 1950, 1953).

H. eurysternus usually breeds on the top of the neck, the base of the horns, the tips of the ears, the brisket, and the tail, but in heavy infestation may occur anywhere on the hair coat (Roberts, 1953). On the other hand, *H. quadripertusus* is confined mainly to the brush, or switch, of the tail as an adult, but may also be found around eyes and in the ears (Bruce, 1947; Capriles and Gaud, 1971). The eggs of *H. quadripertusus* are laid almost exclusively in the tail-switch and the nymphs migrate to the soft skin around the anus, vulva, and eyes (Roberts, 1953). Furthermore, the geographic distribution of the existing records is hardly overlapping. *H. eurysternus* is usually collected in cool and temperate climatic zones probably from domestic forms of *Bos taurus*, but *H. quadripertusus* is found predominantly in subtropical and tropical zones mainly on domestic forms of *Bos indicus* and perhaps hybrids of *B. taurus* and *B. indicus*.

Seven taxonomic characters were measured for the female and eight characters measured

TABLE II. *Means and standard deviations of eight taxonomic characters for* Haematopinus eurysternus *Denny and* H. quadripertusus *Fahrenholz (males); AU = Australia, OR = Oregon, WY = Wyoming, MA = Madagascar, FL = Florida, TA = Taiwan. All units in mm.*

Species	*H. eurysternus*				*H. quadripertusus*			
Populations Sample size	AU 9	OR 4	WY 1	Total 14	MA 10	FL 2	TA 2	Total 14
TBL	2.19	2.51	2.28	2.33 ± 0.13	3.32	3.15	3.09	3.19 ± 0.10
HL	0.58	0.59	0.52	0.56 ± 0.03	0.79	0.76	0.76	0.77 ± 0.01
HW	0.44	0.44	0.40	0.43 ± 0.02	0.51	0.50	0.52	0.51 ± 0.01
TSPL	0.29	0.29	*—	0.29 ± 0.00	0.39	0.37	0.38	0.38 ± 0.01
TSPW	0.22	0.21	*—	0.22 ± 0.01	0.25	0.25	0.28	0.26 ± 0.01
BA	0.54	0.60	0.61	0.58 ± 0.03	0.75	0.73	0.75	0.74 ± 0.01
PL	0.44	0.40	0.41	0.42 ± 0.02	0.59	0.54	0.53	0.55 ± 0.03
SGPL	0.78	0.80	0.71	0.76 ± 0.04	1.12	1.02	1.01	1.05 ± 0.05

* Specimen was overcleared.

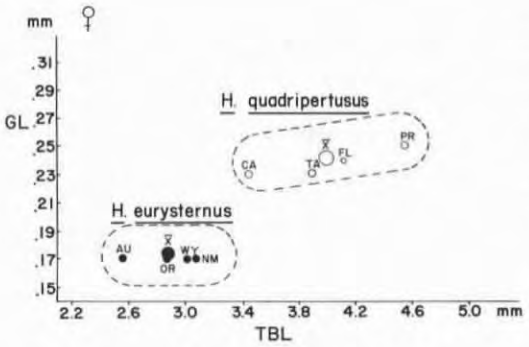

FIGURE 35. Scatter diagram showing discrimination among eight populations of *Haematopinus eurysternus* Denny and *H. quadripertusus* Fahrenholz. AU = Australian population, OR = Oregon population, WY = Wyoming population, NM = New Mexico population, CA = Cambodia population, TA = Taiwan population, FL = Florida population, PR = Puerto Rico population, GL = gonopod length, and TBL = total body length.

for the male. The results are presented in Tables I and II, respectively. Of all of the characters examined, TBL (total body length) and TSPL (thoracic sternal plate length), were most variable for both species; in the females TBL was 4.54 ± 0.14 mm (range 4.27 to 4.75 mm) for *H. quadripertusus* (PR population) and 3.09 ± 0.09 mm (2.94 to 3.18 mm) for *H. eurysternus* (NM population) and TSPL was 0.31 ± 0.06 mm (range 0.27 to 0.34 mm) for *H. quadripertusus* (PR population) and 0.30 ± 0.02 mm (0.25 to 0.33 mm) for *H. eurysternus* (NM population).

As the means of four populations were pooled, TBL was 3.99 ± 0.40 mm (range 3.42 to 4.75 mm) for *H. quadripertusus* and 2.88 ± 0.21 mm (range 2.23 to 3.18 mm) for *H. eurysternus*. Although a difference of 0.95 to 1.33 mm between the smallest and largest individuals of these lice exists, the ranges of TBL for both species do not overlap. The dimensions of the thoracic sternal plate are definitely overlapping between two species: TSPL, 0.31 ± 0.01 mm (range 0.24 to 0.34 mm) for *H. quadripertusus* and 0.3 ± 0.01 mm (range 0.25 to 0.36 mm) for *H. eurysternus*. However, the qualitative features of the thoracic sternal plate are not overlapping between the two species as shown in Figures 17–22. The anterolateral processes of the thoracic sternal plate are prolonged in *H. quadripertusus* but short and rounded in *H. eurysternus*, although considerable infraspecific variations also exist here. The median process of the thoracic sternal plate is strongly enlarged and often prolonged in *H. quadripertusus* in the males. Three other characters, WBG, BA, and PL, are peripherally or wholly overlapping between two species. The dimensions of these characters are easily affected by individual mounting techniques.

To show the level of discrimination between *H. quadripertusus* and *H. eurysternus*, the measurements of TBL and GL are plotted in a scatter diagram (Figs. 34, 35). At first, single populations of *H. quadripertusus* and *H. eurysternus* were compared: PR—Puerto Rico population, and NM—New Mexico population (Fig. 34). There was a complete separation, and no further statistical analysis was needed. The same result was obtained by using the means of TBL and GL for each population of these species as shown in Figure 35. Several other sets of the characters studied gave similar results.

The major taxonomic characters also present definitive differences between the two species. The gonopods of *H. quadripertusus* are long and narrow, while those of *H. eurysternus* are short and compact (Figs. 23–25). The anteromedial process of the ninth abdominal tergite (or dorsal genital plate) is prolonged and acute in *H. eurysternus* (Figs. 26–28). *H. quadripertusus* has four anterior setae on the subgenital plate but *H. eurysternus* has usually six setae (Figs. 32, 33). The number of the anterior subgenital setae in *H. eurysternus* varies from five to seven, but about 80% of the population has six anterior subgenital setae.

Another species, *H. tuberculatus* (Burmeister), may be found on cattle, but is principally an ectoparasite of the water or Indian buffalo (*Bubalus bubalis*). This species has not been found in North America, but has been recorded from many parts of the world where the buffalo has been introduced and domesticated: Egypt, Philippine Islands, Australia, Madagascar, China, and elsewhere. *H. tuberculatus* has been recorded from cattle in Australia (Roberts, 1938, 1950) and in China and Burma (Stimie and van der Merwe, 1968). It has been found that cattle infested with

H. tuberculatus are usually associated with water buffaloes. It is very conceivable that repeated infestation of cattle with *H. tuberculatus* would finally result in the establishment of this species, since *Bos* and *Bubalus* are closely related. This species is a very large louse and total body length ranges from 4.0 to 5.5 mm for females and 3.25 to 4.0 mm for males. *H. tuberculatus* is similar to *H. quadripertusus* in general appearance. However, there are numerous characters in *H. tuberculatus* which differ from other related species. The paratergites are enlarged, and have a tuft of at least five to six, usually eight or more, posterior setae. The thoracic sternal plate is nearly rectangular with two anterolateral processes. In the female, the gonopods are tapering posteriorly, and the median genital plate is irregularly subrectangular or subtrapezoidal with additional posterior sclerite. The basal apodeme of the male is short and wide.

DISCUSSION AND SUMMARY

Roberts (1950) revised *H. quadripertusus* as distinct from *H. eurysternus*, although his case was obviously not convincing enough. He used the total body length, the shape of the thoracic sternal plate, the shape of the head, the male genital plates, and the female apical processes. Stimie and van der Merwe (1968) did not accept the specific status of *H. quadripertusus*, and considered those differences given by Roberts (1950) as too extensively variable. They further suggested that breeding experiments should be carried out to ascertain whether there is justification for separating these two species.

As shown in this paper, there are considerable variations in those characters used by Roberts (1950). However, the range of these variations is not overlapping between the two species in contrast to the arguments by Stimie and van der Merwe (1968), e.g., TBL and GL (Figs. 34, 35). Although a definite overlapping was observed in the dimensions of the thoracic sternal plates, the range of variation in the shape of this structure does not overlap between *H. quadripertusus* and *H. eurysternus* (Figs. 17–19). Many other characters examined in this study provide unquestionable separation between these two species (Figs. 23–33). Furthermore, the primary host, distribution, and microhabitats of these lice strongly suggest that *H. quadripertusus* is definitely distinct from *H. eurysternus*. The taxonomic gap between these two species is as great or even greater than that found among other related species. It should also be mentioned that breeding experiments will not necessarily provide a proof to decide the specific status of *H. quadripertusus*, unless a continuous crossbreeding between these two taxa is ascertained.

The occurrence of the two congeneric species on the same host species is not unusual, particularly on domestic ungulates. The sheep harbors three distinct species of *Linognathus* on different parts of the body: *L. pedalis* (Osborn) on the haired parts of the legs and feet; *L. ovillus* (Neumann) on the parts where wool and hair meet, such as on the belly, tail, and face; and *L. africanus* Kellogg and Paine on the general body surface.

We feel that the present study definitely augments the findings by Roberts (1950). *H. quadripertusus* is unquestionably a distinct species, yet closely related to *H. eurysternus*. We hope that *H. quadripertusus* and *H. eurysternus* will be correctly identified and discussed in future textbooks on parasitology. To aid correct identification of the cattle-infesting species of *Haematopinus*, a taxonomic key with illustrations is provided here.

Key to the cattle-infesting species of *HAEMATOPINUS*

1. Paratergites enlarged, with a tuft of 8 (5 or more) posterior setae (Fig. 31); gonopods tapering posteriorly (Fig. 25); thoracic sternal plate subsquare, about as wide as long or wider than long, without anterior processes (Fig. 19); head short, abruptly constricted at posterior end; female with 2 sclerotized areas between the gonopods partially overlapping (Fig. 25); primary host—water or Indian buffalo ..... *H. tuberculatus* (Burmeister)
   Paratergites rounded or compact, with only 2 posterior setae (Fig. 29); gonopods not tapering posteriorly (Fig. 23); thoracic sternal plate longer than wide (Fig. 17); head long, not constricted abruptly at end; primary host—cattle 2
2. Large species, 3.42 to 4.75 mm long for female (Fig. 6) and 3.04 to 3.52 mm for male (Fig. 5); forehead long; female with

anterolateral processes of thoracic sternal plate elongated (Fig. 17); abdominal tracheal trunks extremely thick; gonopods long and narrow; median genital plate subrectangular, wider than long (Fig. 23); 9th abdominal tergite with anteromedial processes short and blunt (Fig. 26); male subgenital plate with 4 anterior setae (Fig. 32); tropical and subtropical zones including the southern United States ..... *H. quadripertusus* Fahrenholz

Smaller species, 2.23 to 3.18 mm long for female (Fig. 1) and 1.99 to 2.7 mm for male (Fig. 2); forehead short; female with anterolateral processes of thoracic sternal plate not elongated, and rounded (Fig. 18); abdominal tracheal trunks thin; gonopods short and compact; median subgenital plate subtrapezoid, longer than wide (Fig. 24); 9th abdominal tergite with anteromedial processes elongated and acute (Fig. 27); male subgenital plate with 6 (5–7) anterior setae (Fig. 33); temperate or cold climatic zones ..... *H. eurysternus* Denny

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