TRANSFER OF *BOVICOLA TIBIALIS* (PIAGET) (MALLOPHAGA: TRICHODECTIDAE) FROM THE INTRODUCED FALLOW DEER TO THE COLUMBIAN BLACK-TAILED DEER IN CALIFORNIA

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**Abstract:** *Bovicola tibialis* (Piaget), a louse parasite of the European Fallow Deer, was found infesting 3 Columbian Black-tailed Deer at Hopland Field Station, Mendocino Co., California. In 1965, Fallow Deer were introduced onto the Station and were kept in an experimental pasture with Black-tailed Deer. Transfer of lice presumably occurred by direct contact between the two species of deer as they congregated at a feeder within the pasture, and subsequent transfers among Black-tailed Deer accounted for the infestations reported herein. As no males were found among the 18,148 specimens collected, we suggest that parthenogenetic reproduction occurs in *B. tibialis*.

Although lice of the order Mallophaga are usually considered extremely host-specific ectoparasites of birds and mammals, examples exist where lice have transferred and have become established on new host species (Boyd 1951, Clay 1949, 1957, 1962, Emerson 1962, Nelson 1972, Vanzolini & Guimaraes 1955, among others). Secondary infestations are recognized by the anomalous distribution of a species, species-group, or genus of lice on 2 or more unrelated taxa of hosts. Some of these distributions have been interpreted as relic populations of formerly widespread groups (Hopkins 1942, 1949), but other examples cannot be relegated to this interpretation. For example, Murray & Calaby (1971) stated that *Heterodoxus spiniger* (Enderlein, 1909) has now been definitely found on a marsupial, *Wallabia agilis* (Gould), so this louse probably transferred from a macropodid host to dogs, perhaps via the Dingo, and was transported around the world on domestic dogs. Subsequently, this louse has transferred to the Coyote, *Canis latrans* Say, and the Red Wolf, *Canis rufus* (Bartram), in North America (Eads 1948) and the Jackal, *Canis aureus* Linnaeus, in Africa (Hopkins 1949). Until 1971 *H. spiniger* was the only species known in the family Boopidae that was not found exclusively on marsupials. In 1971 Clay described a new genus and species of boopid from the avian host *Casuarus casuarius selaterii* Salvadori, indicating that an interclass transfer of lice had occurred.

Most examples of secondary infestation given by the above authors indicate that these occurred naturally. We conclude that lice, in like manner to free-living animals, have the opportunities and abilities to colonize new habitats. Colonizing species of lice are subject to the same hazards that free-living colonizers face when entering into new areas and habitats. Successful colonization of new hosts by lice will occur when the opportunity for transfer exists, when the niche on the new host is unoccupied or when the invading species of louse is better able to exploit the niche than the occupant louse is, and when the conditions on the new host are satisfactory for survival and reproduction.

Man has been responsible for several successful secondary infestations by lice. Emerson (1962) reported that *Menacanthus stramineus* (Nitzsch, 1818), originally a parasite of wild turkeys, occurs on many gallinaceous birds that are domesticated or maintained in zoological gardens.

Herein we report another case brought about by man of introduction, transfer, and establishment of an exotic louse. We document the secondary transfer of *Bovicola tibialis* (Piaget, 1880) from the Fallow Deer, *Dama dama* (Linnaeus), to the Columbian Black-tailed Deer, *Odocoileus hemionus columbianus* (Richardson), in California. We give the history of the transfer and present circumstantial evidence that this species reproduces parthenogenetically.

Until recently, much confusion existed concerning the proper generic and specific names applied to the lice found on the genus *Odocoileus* in North America (see Scanlon 1960). The correct specific names are now agreed upon (Hopkins 1949, 1960, Scanlon 1960, Emerson 1972), but disagreement still exists concerning the generic names (see Hopkins & Clay 1952). We follow Scanlon (1960) and Emerson (1972) for the names of lice on *Odocoileus* and Werneck (1950) for the name of the louse on

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Fallow Deer.

We consider the records of *Trichodectes tibialis* from deer in California (Kellogg & Ferris 1915, Buckell 1935, Longhurst & Douglas 1955, Taber & Dasmann 1958, Browning & Lauppe 1964) to represent perpetuations of a misdetermination made by Osborn (1896) (Hopkins 1960). These are records of *Tricholipeurus parallelus* (Osborn, 1896).

**Study area**

All deer were collected at the University of California Hopland Field Station in Mendocino County, California. Located 160 km north of San Francisco and 64 km inland from the Pacific Ocean, the Station extends from the floor of the Russian River Valley to the crest of the Mayacamas Mountains, which separate the Russian and Sacramento river drainages. The terrain is hilly and interlaced with small creeks and ravines; the elevation ranges from 150 to 900 m.

During the 3 years of this study, the Black-tailed Deer population numbered from 550 to 900 as estimated by the methods of Connolly (1970). The majority of deer were free roaming, but a few were confined to experimental pastures (approximately 15 to 20 ha) along with various numbers of sheep. In addition to the Black-tailed Deer, there was a small herd of the introduced Fallow Deer on the Station. Their population has ranged from 2 to 11 individuals from 1965 to 1973.

A map of the Station showing the location of pastures and holding pens is given in **Fig. 1**.

**MATERIALS AND METHODS**

A total of 24 male and 47 female Black-tailed Deer ranging in age from 5 months to 12 years were collected year-round over the period from October 1970 to October 1973. Hosts that were not of known age were placed into year classes on the basis of molar wear and teeth eruption on the lower jaw. The deer were shot in the neck or head. The carcasses were kept separated and were transported by truck to Station headquarters, where they were immediately eviscerated and skinned. Hides and heads were placed into separate plastic bags and kept frozen until examined. Each hide was thawed prior to processing and, in most cases, divided into 5 sections: anterior dorsum, anterior venter, posterior dorsum, posterior venter, and tail including the perianal area. These pieces, along with the head, were soaked for 36 to 48 hr in separate beakers of 5% potassium hydroxide to promote sloughing of the hair from the skin. The loose hair, along with the ectoparasites and detritus that it contained, was then heated to boiling in fresh 5% KOH. After being filtered, rinsed in tap water, and suspended in 70% alcohol, the lice were identified, sexed, and counted. When there were several hundred or more lice in a collection, the total number was estimated by suspending the lice in a known volume of alcohol (usually 50 ml) and by counting the number of lice in 10 aliquot samples.

A series of adult specimens of the lice obtained was selected for identification and mounted in either Hoyer’s mountant or Permount. Species of *Tricholipeurus* were identified using the key, descriptions, and figures given by Scanlon (1960). *B. tibialis* was initially identified using the descriptions of Werneck (1950) and Seguy (1944), and our determination was confirmed by Dr K. C. Emerson. Specific characters were visible under the stereomicroscope, and specimens were, thus, easily identified, sexed, and sorted while in alcohol.

**RESULTS**

Of the 71 Black-tailed Deer examined, 37 were infested with *Tricholipeurus parallelus*, 30 with *Tricholipeurus lipoeroides* (Mégnin, 1884), and 3 with
Bovicola tibialis. Nineteen deer were infested with both *T. lipewoides* and *T. parallelus*, and 1 deer was infested with all 3 species of lice. These records for *B. tibialis* represent the first such confirmed record for this louse on a species of Odocoileus and are believed to be the first report of its occurrence in the New World.

In 1974, after the discovery of *B. tibialis* on Black-tailed Deer, we obtained permission to kill and examine 2 of the 10 Fallow Deer for lice. No lice were found. The original pair of Fallow Deer were never examined for lice. Thus, we do not have direct evidence that the Fallow Deer were infested with *B. tibialis*. Because of the known, normal association between Fallow Deer and this louse (Hopkins 1949), there is good circumstantial evidence that the 2 introduced Fallow Deer were infested with *B. tibialis*.

The 3 host individuals infested with *B. tibialis* were confined to the same experimental pasture (S-1). They were killed and examined on 31 January 1973. The 3 deer were heavily infested with adult and nymphal lice, numbering 4818, 5136, and 8194 individuals, respectively. On the 1 deer infested with all 3 species, the overwhelming majority of lice (>98%) was *B. tibialis*. No males were encountered among the 18,148 specimens of *B. tibialis* collected and examined. The distribution of *B. tibialis* on the hosts was more dorsal (61.0%) than ventral (37.5%); lice were scarce on the tail (1.5%) and absent on the head (0%).

**History of the infestation**

The infested Black-tailed Deer. The history of the movements of the 3 infested deer is known. Deer DA1159, a male known to be at least 6 years old, was trapped in the north range on 6 August 1968 and was transferred to S-1 pasture (see map) on that date. Deer DA1160, a 7-1/2 year old male, was born in the holding pen and was transferred to S-1 pasture on 24 September 1968. Deer DA1161, an 11-1/2 year old female, was trapped as a yearling at Coon Lake in 1962, moved to the holding pen until January 1963, and then transferred to S-1 pasture. All 3 deer were shot on 31 January 1973. S-1 and other pastures are bounded by a 2.1-m fence, raised after construction to 3.1 m at points where deer were observed jumping over. Although the deer occasionally jumped these fences, DA1161 remained in S-1 pasture 10 years and the other 2 deer remained approximately 4-1/2 years. Sixteen other deer collected from the S pastures were not infested with *B. tibialis*.

**The introduced Fallow Deer.** One male and 1 female Fallow Deer, both adults of unknown age, were bought from Santa’s Village, Scotts Valley, California, on 19 February 1965 and were released into D-4 pen (fig. 1). In April 1972, 10 Fallow Deer, the descendent of the original pair, were released onto the Station and adjacent property. These deer were recaptured and were placed in pastures S-4, S-5, and S-6 on 28 November 1972. The gate to S-2 pasture from these pastures was opened on 18 December 1972 to allow the Fallow Deer access to S-2, but deer were not observed in S-2 until late December 1972. S-2 is adjacent to S-1 with a 700-m common boundary fence of 2.1 m in height. Deer have not been known to jump this segment of fence since its construction. As all deer in these pastures were individually marked to facilitate periodic censuses, any deer crossing the fence would have been discovered. The last Black-tailed Deer in S-2 pasture prior to the introduction of the Fallow Deer were removed on 5 December 1972.

The 3 Black-tailed Deer infested with *B. tibialis* were in S-1 pasture for approximately a month, while the Fallow Deer occupied the adjacent S-2 pasture (from late December 1972 to 31 January 1973). No contact between the Black-tailed Deer and Fallow Deer along the fence was observed during this period. Our opportunities for such observations were quite limited.

**Methods of transmission.** We assume that transfer of *B. tibialis* occurred through direct contact between individuals of the 2 species of deer, as this is the normal method of intraspecific transfer of lice (Hopkins 1949, Matthiasse 1946, Murray 1966, Samuel & Trainer 1971). Presumably, any interspecific contacts between the deer in the D-4 pen went unrecorded during the approximately 7-year period that the 2 species were present in this D-4 pen. Opportunities for direct contact were enhanced in D-4 pen, as deer were fed from feeders, and deer congregate at the feeders in this pen and in the holding pen. Deer forage naturally in the S pastures.

Peus (1933) found *B. tibialis* phoretic on mosquitoes. Although phoresy may be a plausible method of interhost transfer, direct contact between hosts is the more likely method.

**Probable course of transmission.** Although *B. tibialis* was found on only 3 of 71 Black-tailed Deer, the large number of nymphs and adults on each host indicates that the lice were well established. The exact course of the transfer is not definitely known. Of several possibilities, one has credence. The
Black-tailed Deer from which *B. tibialis* were recovered had no opportunity for direct contact with Fallow Deer, except possibly through the fence separating S-1 and S-2 pastures during the month prior to necropsy. This seems unlikely in view of the recorded burdens of *B. tibialis*. Again, at least 1 of the 3 infested Black-tailed Deer might have become infested by direct contact with other infested Black-tailed Deer that were held with the Fallow Deer at D-4 during 1965–1968 and subsequently were moved to the holding pen where DA1160 was born. Deer were moved from D-4 to the holding pen during this period. Opportunities for DA1160 to acquire *B. tibialis* existed during direct contact with infested deer, particularly when congregating at the feeders. Presumably DA1159 and DA1161 acquired *B. tibialis* from DA1160 when the latter deer was transferred to S-1 pasture. This explanation accounts for the linkage of direct contacts between the Fallow Deer and the 3 infested Black-tailed Deer. Because other Black-tailed Deer appear to be involved in the chain of infestation, undoubtedly other deer at the Station are infested with *B. tibialis*, in addition to the 3 recorded herein.

**Evidence for parthenogenetic reproduction.** The absence of male lice among the thousands of *B. tibialis* collected from all 3 infested Black-tailed Deer strongly suggests the possibility of parthenogenetic reproduction in this species. Although Piaget (1880) described a male in his original description of *Trichodectes tibialis* (= *B. tibialis*), he provided drawings of the female only. Since his description, other workers have been unable to locate additional males, which prompted Werneck (1950) to remark that male specimens of *B. tibialis* should be located and examined to confirm Piaget’s description. Dr Clay (pers. commun.) informed us that no male of this species exists in the Piaget collection. She speculates that Piaget’s description of the male was based on a distorted female specimen or a nymph.

Discovery of males of *B. tibialis* would not negate the possibility of parthenogenesis, since related lice, *Bovicola bovis* (Linnaeus, 1758), *Bovicola equi* (Denny, 1842), and certain other species, reproduce parthenogenetically but produce males during periods of rapid increase in populations (Matthysse 1946, Hopkins 1949). A similar mode of reproduction in *B. tibialis*, if it occurs, would help account for the transfer to Black-tailed Deer, since only 1 female louse would need to be transferred from a Fallow Deer to initiate infestation.

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**Literature Cited**


