The \textit{Pedicinus} species (Insecta, Phthiraptera, Anoplura, Pedicinidae) on douc langurs (\textit{Pygathrix} spp.)

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\textbf{Key words:} \textit{Pygathrix} spp., lice, \textit{Pedicinus}, new species, Vietnam

\textbf{Summary}

All three species of Southeast-Asian douc langurs (\textit{Pygathrix} spp.) harbor a host-specific species of \textit{Pedicinus} (\textit{Neopedicinus}). Using freshly collected material of known provenance, these were identified as \textit{Pedicinus tongkinensis} Mey, 1994 ex \textit{Pygathrix nemaeus}, \textit{Pedicinus atratulus} nov. spec. ex \textit{Pygathrix nigripes}, and \textit{Pedicinus curtipenitus} nov. spec. ex \textit{Pygathrix cinerea}. The three species described here are closely related to each other and belong to the newly created “ ancoratus species group” within the subgenus \textit{Neopedicinus}.

\textbf{Introduction}

The colobine genus of the douc langurs \textit{Pygathrix} E. Geoffroy St.-Hilaire, 1812 is endemic to Indochina. Three monotypic species are distinguished (Roos & Nadler, 2001, Nadler et al., 2003, Nadler, 2007). The only lice of the genus \textit{Pedicinus} found on these monkeys until now were from the red-shanked douc langur \textit{Pygathrix nemaeus} (Mey 1994) (Fig. 1). But thanks to Tilo Nadler’s special interest in parasite infestation in monkeys, \textit{Pedicinus} has now also been found on \textit{Pygathrix nigripes} (Fig. 2) and \textit{P. cinerea} (Fig. 3) in the wild or in captivity at the Endangered Primate Rescue Center in Cuc Phuong National Park in Vietnam. The results of the taxonomic treatment of these new findings are presented here.

\textbf{Material and Methods}

All material was collected by Tilo Nadler and his co-workers mostly from freshly dead douc...
Fig.1. Red-shanked douc langur (*Pygathrix nemaeus*). Photo: Tilo Nadler.

Fig.2. Black-shanked douc langur (*Pygathrix nigripes*). Photo: Tilo Nadler.

Fig.3. Grey-shanked douc langur (*Pygathrix cinerea*). Photo: Tilo Nadler.
langurs at the Endangered Primate Rescue Center (EPRC), Cuc Phuong National Park. The collected material was dry-stored then preserved as permanent specimens in Canada balsam, which are now deposited in the animal louse collection of the Natural History Museum in Rudolstadt (NMR) (Thüringen), Germany. Examination methodology (especially measurements), terminology, and systematics approach follow the revision of Kuhn & Ludwig (1967).

**Pedicinus (Neopedicinus) on douc langurs**

The *Pedicinus* samples collected from all three *Pygathrix* species (Cercopithecidae, Colobinae) in Vietnam belong to the subgenus *Neopedicinus* Fahrenholz, 1916 (originally introduced into the literature as a genus).

Besides *Neopedicinus*, the subgenera *Pedicinus* Gervais, 1844 (with one polytypic species on Asian macaques *Macaca* spp.) and *Parapedicinus* Kuhn & Ludwig, 1967 (with at least 3 mono- and 2 polytypic species on African and Asian Cercopithecinae and Colobinae) are distinguished (Kuhn & Ludwig, 1967; Mey, 1994).

Following examination of the material presented here, it is gradually becoming apparent that *Pedicinus ancoratus* Ferris (Fig. 4) is most likely not a polytypic species, as Mey (1994) had to assume. It seems much more to be the case that several closely related *Pedicinus* species occur on Asian colobines, which can be brought together in the *ancoratus* species group (Table 1). Along with the eponymous species *P. tongkinensis*, which is here raised to species rank, this encompasses the two newly described species below. All four have in common the characteristic form of the end of the penis (Fig. 5).

![Fig.4. *Pedicinus (Neopedicinus) ancoratus* Ferris, 1934 ex *Trachypithecus cristatus* (Raffles) from Pulo Sebang, East-Sumatra. 4-1: Male (holotype); 4-2: female (alloptoid) after Kuhn & Ludwig, 1967: 184.](image-url)

<table>
<thead>
<tr>
<th>Pedicinus species</th>
<th>Type host</th>
<th>Other hosts</th>
<th>Geographical distribution</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. ancoratus</td>
<td>Trachypithecus cristatus (Raffles, 1821)</td>
<td>T. auratus (E. Geoffroy, 1812); T. francoisi (Pousargues, 1898); Presbytis rubicunda (Müller, 1838); Semnopithecus entellus (Dufresne, 1797)</td>
<td>Sumatra, some islands in the Riau Archipelago, Borneo, western coastal strip of peninsula Malaysia</td>
<td>1, 2</td>
</tr>
<tr>
<td>P. tongkinensis</td>
<td>Pygathrix nemaeus (Linnaeus, 1771)</td>
<td>unknown*</td>
<td>Vietnam, Laos, Cambodia</td>
<td>3</td>
</tr>
<tr>
<td>P. atratulus n. sp.</td>
<td>Pygathrix nigripes (Milne-Edwards, 1871)</td>
<td>unknown</td>
<td>Vietnam, Cambodia</td>
<td>this paper</td>
</tr>
<tr>
<td>P. curtipenitus n. sp.</td>
<td>Pygathrix cinerea</td>
<td>unknown</td>
<td>Vietnam</td>
<td>this paper</td>
</tr>
</tbody>
</table>

Fig.5. Pedicinus spp., penis. Scale 0.1 mm.
5-9 to 5-13: P. (Neopedicinus) atratulus n. sp. (5-9: M. 4527. m; 5-10: 4527. f; 5-11: 4527. h; 5-12: 4527. c; 5-13: 4527. b.)
5-14 to 5-17: P. (Neopedicinus) curtipenitus n. sp. (5-14: holotype; 5-15: M. 5943; 5-16: 5943. a; 5-17: 5943. c.)
5-18 and 5-19: P. (Neopedicinus) tongkinensis Mey (5-18: M. 4225. c; 5-19: 4225. b.)
In their revision of *Pedicinus*, Kuhn & Ludwig (1967) do not differentiate any species groups, but instead only the higher category of subgenera (see above). They divide some species (like *P. pictus*) into subspecies, although these differ clearly from each other, particularly in their genital morphology. However, such differences, which mostly arise in geographic-hospitalic isolation, are strong indications for the existence of reproductive isolation, which can only be the case when separate species are involved. If two reproducing populations of *Pedicinus* are found together on the same host species or host individual then they are of two distinct species.* Perhaps this was the reason why already Ledger (1980) advocated treating the forms of African *P. pictus* in particular as species in their own right. While Durden & Musser (1994a) pointed this out, in their own Anoplura checklist they consistently synonymized all subspecies (with the exception of *Pediculus humanus humanus* and *P. h. capitis*!). The conclusion to be drawn would seem to be that there are no subspecies in the Anoplura. But it is surely more correct to say that Durden & Musser (1994a, b) make no, or only very limited use of this infraspecific category with regard to Anoplura (with the one exception!). Whether Anoplura species really do tend not to be polytypic (or hardly so) is a question that should remain in the focus of systematic and taxonomic interest. My experience, however, indicates that this is not the case.

### Results

1. **Pedicinus (Neopedicinus) atratulus** nov. spec.
   
   Fig. 5-9 to 5-13; 6-3; 6-5; 7-6; 8-24 to 8-28; 9-32 to 9-37; Tables 1 to 3
   
   Type host: *Pygathrix nigripes* (Milne-Edwards, 1871)

### Material

30 males, 20 females, 21 larvae (slides M. 4227. a-h, j-s) from one freshly dead host individual, 13. 2. 2001 EPRC, Cuc Phuong National Park, Vietnam, leg. T. Nadler.

Holotype, male (M. 4527. a), allotypoid (M. 4527. o, above) and paratypes in NMR.

### Description

Habitus very similar to *P. ancoratus* Ferris (Fig. 4-1). Head length and total length as in Table 2 (males) and Table 3 (females).

Sclerotization of freshly dead or dry-stored individuals black-brown, light brown following maceration in potassium lye. Contrasted with the brownish color in *Pedicinus tongkinensis* ex *Pygathrix nemaeus* and *P. curtipenitus* ex *Pygathrix cinerea* this difference in the natural body coloration is very striking.

The pigmentation of paratergal plate iv, which protrudes scale-like on both sides (Fig. 6-3 and 6-5), is different in males and females after maceration. In females (n = 15) the paratergalia iv (see Fig. 6-5) are slightly brownish on both sides; in only one individual were they opaque on one side (colorless), and on the other side slightly brownish. In the clearly smaller male (n = 15) left and right paratergalia iv are mostly opaque, in the larvae (n = 11) always so. Only in one male was paratergal plate iv opaque on one side but on the other brownish, while in the other 10 males this weak coloration was present on both sides.

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* Hence it is unacceptable to regard the human body louse and head louse, which differ only very slightly genetically and in their morphological structure but live on the same host, as subspecies of a single species. *Pediculus humanus* Linnaeus and *Pediculus capitis* Degeer are quite clearly two (biological) species.
The variable form of the hypandrium is illustrated in Fig. 8-24 to 8-28, and the number of its isolated bristles shown in Table 2. Similarly, for the hypogynium see Fig. 9-32 to 9-37, and Table 3. The male genital apparatus is shown in Fig. 7-6, and the penis in Fig. 5-9 to 5-13. The v-shaped pigmented area in the cranial part of the penis is prominent.

**Differential diagnosis**

The taxa in the *ancoratus* species group can be differentiated by combinations of the following characters: body coloration, size and pigmentation of the paratergalia on abdominal segment iv, number of isolated bristles on the subgenital plates (hypandrium, hypogynium), form of the subgenital plates, and structures of the genital apparatus, the penis in particular. There appear to be no striking differences between the species in the ancoratus group in length (0.41 - 0.45 mm) and width (0.15 - 0.17 mm) of the male genital apparatus.

In contrast to the light brown *ancoratus*, *tongkinensis*, and *curtipenitus* n. sp., in *atratulus* n. sp. the sclerotizations are black-brown; freshly dead and dry-stored adults and larvae (!) even appear to be almost completely blackish in color.

The great majority of *atratulus* n. sp. males possess an opaque, relatively small paratergum on each side of abdominal segment iv (Fig. 6-3). Despite the lighter body coloration of *P. ancoratus*,

### Table 2. Body dimensions (mm) and number of subgenital plate setae (isolated bristles of hypandrium, "Inselborsten") of males of Pediculus spp. ex Pygathrix spp. (* n = 19; ** n = 20).

<table>
<thead>
<tr>
<th></th>
<th>Pediculus atratulus n. sp. (n = 30)</th>
<th>Pediculus curtipenitus n. sp. (n = 8)</th>
<th>Pedicinus tongkinensis Mey (n = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>holotype</td>
<td>x variation (min.-max.)</td>
<td>holotype x variation (min.-max.)</td>
<td>holotype x variation (min.-max.)</td>
</tr>
<tr>
<td>total length</td>
<td>1.81 1.649 C1.47 - 1.99</td>
<td>1.75 1.693 1.60 - 1.75</td>
<td>1.72 1.578 1.47 - 1.72*</td>
</tr>
<tr>
<td>head length</td>
<td>0.56 0.532 0.50 - 0.57</td>
<td>0.56 0.542 0.53 - 0.56</td>
<td>0.51 0.516 0.47 - 0.54**</td>
</tr>
<tr>
<td>penis length</td>
<td>0.205 0.184 0.160 - 0.205</td>
<td>0.186 0.165 0.148 - 0.186</td>
<td>0.194 0.187 0.171 - 0.211</td>
</tr>
<tr>
<td>penis width</td>
<td>0.046 0.046 0.046 - 0.051</td>
<td>0.046 0.048 0.046 - 0.051</td>
<td>0.057 0.051 0.046 - 0.057</td>
</tr>
<tr>
<td>subgenital plate setae</td>
<td>10 9.1 07 - 12</td>
<td>11 10.88 09 - 13</td>
<td>8 7.62 06 - 10</td>
</tr>
</tbody>
</table>

### Table 3. Body dimensions (mm) and number of subgenital plate setae (isolated bristles of hypogynium, "Inselborsten") of females of Pediculus spp. ex Pygathrix spp.

<table>
<thead>
<tr>
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<th>Pediculus curtipenitus n. sp. (n = 8)</th>
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</tr>
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<tbody>
<tr>
<td>holotype</td>
<td>x variation (min.-max.)</td>
<td>holotype x variation (min.-max.)</td>
<td>holotype x variation (min.-max.)</td>
</tr>
<tr>
<td>total length</td>
<td>2.14 2.115 1.84 - 2.37</td>
<td>2.2 2 1.84 - 2.50</td>
<td>2.34 2 1.78 - 2.34</td>
</tr>
<tr>
<td>head length</td>
<td>0.62 0.604 0.57 - 0.65</td>
<td>0.63 0.604 0.57 - 0.63</td>
<td>0.6 0.605 0.57 - 0.65</td>
</tr>
<tr>
<td>subgenital plate setae</td>
<td>7 7.11 05 - 09</td>
<td>9 7.25 05 - 09</td>
<td>8 8.83 07 - 13</td>
</tr>
</tbody>
</table>

The variable form of the hypandrium is illustrated in Fig. 8-24 to 8-28, and the number of its isolated bristles shown in Table 2. Similarly, for the hypogynium see Fig. 9-32 to 9-37, and Table 3. The male genital apparatus is shown in Fig. 7-6, and the penis in Fig. 5-9 to 5-13. The v-shaped pigmented area in the cranial part of the penis is prominent.
tongkinensis, and curtipenitus n. sp. (even if altered by the mounting process) their patergalia iv are never opaque in the adult animal.

The mean number of isolated bristles (“Inselborsten”) differs between atratulus n. sp., curtipenitus n. sp., and tongkinensis in both sexes (Tables 2 and 3). While atratulus n. sp. and curtipenitus n. sp. males have on average around 10 (9-13), in tongkinensis this figure is 8 (6-10) (Table 2). Ancoratus too never has more than 10 isolated bristles (Kuhn & Ludwig, 1967). In the females of all species these bristle ratios are reversed. P. tongkinensis has the most, with 7-13, and atratulus n. sp. and curtipenitus n. sp. have only 5-9 (Table 3).

Despite the considerable variability in the form of the hypandrium, it is striking that while its cranial, arm-like extensions in atratulus n. sp. and tongkinensis are well developed on both sides (Fig. 8-24 to 8-31), in curtipenitus n. sp. they are always strongly reduced on one side only and their weakly pigmented, ragged looking contours are hardly visible (Fig. 8-20 to 8-23).

The variablity in the form of the hypogynium in atratulus n. sp. and curtipenitus n. sp. is shown in Fig. 9-32 to 9-43. A very similar diversity can be seen in tongkinensis and probably also in the ancoratus group. Hence it is difficult to regard this character as a diagnostic species trait within the ancoratus group. However, one very interesting fact is that the presence of a lateral-caudal sclerite strip in some (apparently only adults) P. ancoratus females could not be confirmed in a single individual of the other three species examined.
In the structures of the male genital apparatus, especially the penis, all species in the ancoratus group show their own peculiarities. With an average length of 0.17 mm, *P. curtipenitus* n. sp. has the shortest penis. The width is the same as in *atratulus* n. sp. but it is greater in *tongkinensis*. *P. atralatus* n. sp. and *tongkinensis* (and presumably also *ancoratus*) do not differ in penis length (Table 2, Fig. 5-9 to 5-19). In its cranial section, the penis of *atratulus* n. sp. has a darkly pigmented v-shaped area, which is lacking in all other species of the *ancoratus* group (Figs. 5-9 to 5-13). The penis of *P. ancoratus* – according to Kuhn & Ludwig (1967; Fig. 34) – appears to be very similar in form and length to that of *curtipenitus* n. sp. On the whole there seem to be very slight differences between the species in the form of the paramera and the pseudopenis, although it cannot be completely excluded that they are an artifact of the preservation process (Fig. 7-6 to 7-8).

In the bristle pattern of the abdominal segments (especially segment v), I could discern no consistent differences between all the species in the ancoratus group. Nevertheless, this important character, which can prove its usefulness only in very carefully preserved individuals, needs to be borne in mind.

**Derivatio nominis**

From the blackish body coloration (= Lat. *atratulus*) that is only preserved on the sclerotizations following maceration in potassium lye.
2. *Pedicinus* (Neopedicinus) *curtipenitus* nov. spec.

Fig. 5-14 to 5-17; 6-4; 7-7 and 7-8; 8-20 to 8-23; 9-38 to 9-43; Tables 1 - 3

Type host: *Pygathrix cinerea* Nadler, 1997 (= *Pygathrix nemaeus cinereus* Nadler, 1997)

Material


Holotype, male (M. 4785. c), allotypoid (M. 5943. e, left) and paratypes in NMR.
Description

Habitus very similar to *P. ancoratus* Ferris (see Fig. 4-1). Body coloration light brown. Head length and total length as in Table 2 (males) and Table 3 (females).

Paratergalia v-vii as in Fig. 6-4. Hypandrium and hypogynium see Fig. 8-20 to 8-23 resp. 9-38 to 9-43. Bristle pattern of the subgenital plates as in Tables 2 and 3. Genital apparatus (Fig. 6-4) with relatively short penis (Fig. 5-14 to 5-17).

Differential diagnosis

See *P. atratulus* n. sp.

Derivatio nominis

Based on the relatively short penis, a Latin combination from curtus (= shortened) and penitus (= possessing a penis).

Fig. 5-18 and 5-19, 8-29 to 8-31, Tables 1 to 3
Type host: *Pygathrix nemaeus* (Linnaeus, 1771) [monotypic!]

Material

(here new records since 1993 listed only; see Mey, 1994: 83). 8 males, 18 females, 3 larvae from two freshly dead host individuals. 1: 8 males, 12 females, and 3 larvae (slides M. 4225. a-d) ex one dead *Pygathrix nemaeus*, autumn 1997, EPRC, Cuc Phuong National Park, Vietnam. 2: 6 females (slides M. 4488. a-b) ex one dead *Pygathrix nemaeus* (EPRC 6-27), Cuc Phuong National Park, Vietnam, leg. T. Nadler.

*P. tongkinensis* was introduced into the scientific literature as a subspecies of *P. ancoratus* Ferris. However, in a comparison of morphological characters with *P. atratulus* n. sp. and *P. curtipenitus* n. sp. in particular, differences became apparent (see Fig. 5-9 to 5-19, 8-29 to 8-31, Tables 2 and 3, and the differential diagnosis of *P. atratulus* n. sp.) that would appear to justify its being treated here as a full species.

Discussion

According to molecular genetic analysis, *Pygathrix nigripes* is an older species than the species pair *P. nemaeus* / *P. cinerea* (Roos & Nadler, 2001; Roos, 2003). All three douc langurs are host to their own species of *Pedicinus*, which resemble each other closely in habitus and morphology and almost certainly share a common ancestor. To what extent this reflects the phylogenesis of their hosts cannot presently be ascertained from the available morphological findings. The study of additional *Pedicinus* taxa would be necessary, in particular those living on Asian colobines, in which less than 15% of an estimated 44 species (Duff & Lawson, 2004) have been examined for ectoparasites. Genital structures, paratergalia, isolated bristles, and also body coloration in *P. atratulus* n. sp., *P. curtipenitus* n. sp., and *P. tongkinensis* all show differences, which would clearly be useful in a later phylogenetic character analysis. From the parasitophyletic viewpoint however, these *Pedicinus* species supply us with excellent evidence that their hosts are valid species and not subspecies as was earlier thought.

In this connection, one noteworthy fact is that *Pygathrix nemaeus* and *P. cinerea*, as well as *P. cinerea* and *P. nigripes*, occur parapatrically and that there are occasional records of hybridization between them (Nadler et al., 2003). Therefore in those contact zones it is clear that a switch of host by *tongkinensis* and *curtipenitus* on the one hand, and by *curtipenitus* and *atratulus* on the other, theoretically cannot be excluded. However evidence of two *Pedicinus* (Neopedicinus) species living together permanently on one *Pygathrix* species would be extremely unlikely. Whether these *Pedicinus* species ever mate with each other on contact thus creating a mixed population remains unknown.

What is striking in the currently known hospitalic distribution of the *ancoratus* species group is that one species is polyxenous (= on more than one host) while the other three are monoxenous (= on one host only) (Table 1). In my opinion it must be doubted whether this supposed geographic-hospitalic distribution of *Pedicinus ancoratus* agrees with the facts. The reported cases of polyxeny are probably not even instances of secondary infestation but rather of so-called stragglers.

Among the many *Pedicinus atratulus* n. sp. individuals collected from a heavily infested black-
shanked douc langur was an immature female Pedicinus (Parapedicinus) species (specimen M. 4527. i). Perhaps this record is traceable to a contamination of collected material in the primate center.

In the light of this study, I would like to appeal to all interested primatologists to give some of their attention also to the lice living on primates, and to carefully collect such material (of known provenance!) for use in phthirapterological research.

Acknowledgments

I am most sincerely grateful to Tilo Nadler (Endangered Primate Rescue Center, Cuc Phuong National Park) for his diligent collecting of Pedicinus specimens, which allowed me to examine and evaluate thus making the present study possible. I also thank Brian Hillcoat (Berlin) for the translation of the German manuscript.

References


