

Research article

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The flea collection of the Museum of Zoology, Sapienza University of Rome (Insecta: Siphonaptera)

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Abstract

The Museum of Zoology of Sapienza University of Rome (MZUR) houses a collection of fleas encompassing about 1300 specimens, representing 132 species and 10 families. Most of these specimens were collected in Italy and neighboring countries. The flea collection has been digitalized and is now accessible through a freely available dataset, which includes information from the labels of each preserved specimen. Additionally, an overview of the collection, a checklist of the preserved taxa and photos of selected specimens are provided.

Keywords: digitalization, entomological collection, ectoparasites, faunal records, blood-sucking insects.

Introduction

Siphonaptera Latreille, 1825 (fleas) is a clade of antliophoran insects, whose adults are specialised hematophagous ectoparasites of birds and mammals. Fleas exhibit moderate diversity, with approximatively 2185 described species classified in 19 families (Whiting et al. 2008; Galloway 2018). While fleas are cosmopolitan, only three species with a broad host range and a close association with humans and their pets are widespread, i.e., *Ctenocephalides felis* (Bouche, 1835), *C. canis* (Curtis, 1826) and *Pulex irritans* Linnaeus, 1758 (Medvedev 1996). Adult fleas are characterised by being secondarily wingless, nearly blind and laterally compressed. In most cases, the whole body is designed to move easily forward in the fur of the host and to resist its grooming attempts. The tarsi bear very large, toothed and robust claws, which constitute the main means of attachment to the host. Many fleas carry combs of specialized bristles (ctenidia), which on the one hand facilitate forward movement through the host's hair or feathers, on the other hand they can become entangled when the host tries to remove the flea by pulling it back (Beaucornu & Launay 1990; Galloway 2018). Fleas are renowned for their jumping prowess, which is instead poorly

developed or completely absent in species associated with hosts that live in underground burrows. Some fleas are able to jump up to 100 times their body length. What was the wing joint in the ancestors of fleas, with its supply of resilin, an elastomeric protein present in all winged insects, has been restructured and incorporated into the jumping mechanism, which includes, among other things, highly developed metathoracic legs (Rothschild et al. 1973).

Fleas have been studied for their importance in medical and veterinary fields as vectors of pathogens. Especially famous is *Xenopsylla cheopis* (Rotschild, 1903), the Oriental rat flea, an ectoparasite of rodents well-known as the primary vector of the bacteria *Yersinia pestis* and *Rickettsia typhi*, the agents of bubonic plague and murine typhus, respectively. Moreover, several flea species are involved in the transmission of parasites and pathogens of veterinary relevance, such as *Ctenocephalides felis*, the intermediate hosts of the dog tapeworm *Dipylidium caninum* (Linnaeus, 1758), and *Spilopsyllus cuniculi* (Dale, 1878), the vector of the *Myxoma virus* infecting rabbits (Galloway 2018).

Despite their significance in medical and veterinary fields, little is known about species diversity, and little has been done regarding the conservation of fleas (Galloway 2018). Although the extinction risk has never been

assessed for any flea species (as for other hematophagous ectoparasites) it is conceivable that many species will be soon endangered or extinct, following the rarefaction or extinction of their mammal and bird hosts (Lewis 1998; Galloway 2018). Therefore, any study focusing on the distribution and presence of flea species could help to better understand these overlooked, yet emblematic, insects.

The aim of this study is to provide the scientific community with a geo-referenced and taxonomically validated database of species occurrences, based on the flea collection of the Museum of Zoology of “Sapienza” University of Rome (MZUR). This involved documenting the label data for each specimen and providing photographs of selected specimens of each species. Several records had already been published as non-georeferenced data in two faunistic works (Mei 1996, 1997). The present study highlights the importance of small natural history museums in facilitating research into overlooked components of our biodiversity.

Materials and methods

The MZUR collection was created by MM in the 90s of the last century, gathering, preparing and identifying the fleas preserved in alcohol in the warehouses of the Museum, coming from more or less occasional collections carried out by entomologists of the Department, especially in Italy and in neighboring countries. Additionally, over the years, specimens from other biogeographic regions have been acquired through collections made by mammal researchers of the Department and by exchanges with other specialists.

Most of the specimens are mounted in Canada Balsam on microscope slides, and several samples are preserved in glass vials with 70% ethanol. The fleas were identified by MM, with the exception of several specimens identified and donated from Prof. J.-C. Beaucournu (France, Rennes).

Each specimen is recorded in a database entry containing details such as the collection location and date, geographic coordinates, sex, life stage, relevant taxonomic information, and associated host (if applicable). We photographed either one individual or, if possible, both a male and a female of every species using a ZEISS Axio Zoom. V16 optical microscope. The taxa are listed alphabetically.

Results

The dataset covers over 1290 specimens, representing 132 species in 10 out of the 19 currently recognized families of Siphonaptera. In particular, the collection includes 85 (71 species and 14 “subspecies”) of the 102 taxa reported for the Italian fauna (Iori et al. 1995) (i.e. 80 species and 22 “subspecies”) and the relevant data offer a significant insight into the distribution of several species in the region (Mei 1995, 1996).

Collection dataset

The digitalized dataset of MZUR Siphonaptera collection is available at: <https://doi.org/10.13133/UNIROMA1/HU-JR0L>

Table 1 – Checklist of species of Siphonaptera preserved in MZUR collection.

Family	Species	Figure
Ceratophyllidae	<i>Amalareus arvicolae</i> (Ioff, 1948)	Fig. 1 A
	<i>Amalareus penicilliger</i> (Grube, 1851)	Fig. 1 B
	<i>Callopsylla saxatilis</i> (Ioff et Argyropulo, 1934)	Fig. 1 C
	<i>Ceratophyllus borealis</i> Rothschild, 1906	Fig. 1 D, E
	<i>Ceratophyllus chasteli</i> Beaucournu, Monnat & Launay, 1982	Fig. 1 F, G
	<i>Ceratophyllus columbae</i> Gervais, 1844	Fig. 1 H, I
	<i>Ceratophyllus fringillae</i> Walker, 1856	Fig. 1 J, K
	<i>Ceratophyllus gallinae</i> (Schrank, 1803)	Fig. 1 L, M
	<i>Ceratophyllus hirundinis</i> Curtis, 1826	Fig. 1 N, O
	<i>Ceratophyllus rusticus</i> Wagner, 1903	Fig. 2 A, B
	<i>Ceratophyllus sciurorum</i> (Schrank, 1803)	Fig. 2 C, D
	<i>Dasypsyllus gallinulae</i> (Dale, 1878)	Fig. 2 E, F
	<i>Glaciopsyllus antarcticus</i> Smit & Dunnet, 1962	Fig. 2 G, H
	<i>Libyastus</i> sp. Jordan, 1936	Fig. 2 I
	<i>Megabothris turbidus</i> (Rothschild, 1909)	Fig. 2 L, M
	<i>Myoxopsylla laverani</i> (Rothschild, 1911)	Fig. 2 J, K
	<i>Nosopsyllus barbarus</i> (Jordan & Rothschild, 1912)	Fig. 2 N, O
	<i>Nosopsyllus fasciatus</i> (Bosc, 1800)	Fig. 3 A, B
	<i>Nosopsyllus londiniensis londiniensis</i> (Rothschild, 1903)	Fig. 3 C, D
	<i>Paraceras melis</i> (Walker, 1856)	Fig. 3 E, F

Family	Species	Figure
	<i>Tarsopsylla octodecimdentata</i> (Kolenati, 1863)	Fig. 3 G
Ctenophthalmidae	<i>Ctenophthalmus agyrtes agyrtes</i> (Heller, 1896)	Fig. 4 A, B
	<i>Ctenophthalmus agyrtes culter</i> Beaucournu, Valle & Launay, 1981	Fig. 4 C
	<i>Ctenophthalmus agyrtes impavidus</i> Jordan, 1928	Fig. 4 D, E
	<i>Ctenophthalmus agyrtes provincialis</i> Rothschild, 1910	Fig. 4 F, G
	<i>Ctenophthalmus agyrtes sardiniensis</i> Ioff, 1928	Fig. 4 H, I
	<i>Ctenophthalmus agyrtes</i> (Heller, 1896) ssp. (Česká Kamenice, Bohemia)	Fig. 4 J
	<i>Ctenophthalmus agyrtes verbanus</i> Jordan & Rothschild, 1920	Fig. 4 K, L
	<i>Ctenophthalmus andorrensis</i> Smit, 1960	Fig. 4 M, N
	<i>Ctenophthalmus apertus apertus</i> Jordan & Rothschild, 1921	Fig. 4 O, 5 A
	<i>Ctenophthalmus assimilis assimilis</i> (Taschenberg, 1880)	Fig. 5 B, C
	<i>Ctenophthalmus baeticus arvernus</i> Jordan, 1931	Fig. 5 D, E
	<i>Ctenophthalmus bisoctodentatus bisoctodentatus</i> Kolenati, 1863	Fig. 5 F, G
	<i>Ctenophthalmus bisoctodentatus certus</i> Beaucournu, 1979	Fig. 5 H, I
	<i>Ctenophthalmus congener congener</i> Rothschild, 1907	Fig. 5 J, K
	<i>Ctenophthalmus congener grulichii</i> Beaucournu, 1964	Fig. 5 L, M
	<i>Ctenophthalmus egregius egregius</i> Peus, 1964	Fig. 5 N, O
	<i>Ctenophthalmus egregius garganus</i> Beaucournu & Grulich, 1976	Fig. 6 A
	<i>Ctenophthalmus niethammeri</i> Beaucournu, Valle & Launay, 1981	Fig. 6 B, C
	<i>Ctenophthalmus nivalis nivalis</i> Rothschild, 1909	Fig. 6 D, E
	<i>Ctenophthalmus nivalis helvetius</i> Smit, 1963	Fig. 6 F
	<i>Ctenophthalmus nobilis nobilis</i> (Rothschild, 1898)	Fig. 6 G, H
	<i>Ctenophthalmus orphilus orphilus</i> Jordan & Rothschild, 1923	Fig. 6 I, J
	<i>Ctenophthalmus orphilus dolomiticus</i> Jordan & Rothschild, 1923	Fig. 6 K, L
	<i>Ctenophthalmus russulae russulae</i> Jordan & Rothschild, 1912	Fig. 6 M, N
	<i>Ctenophthalmus russulae galloibericus</i> Beaucournu & Lumaret, 1972	Fig. 6 O, 7 A
	<i>Ctenophthalmus savii savii</i> Jordan & Rothschild, 1921	Fig. 7 B, C
	<i>Ctenophthalmus savii matilei</i> Beaucournu & Grulich, 1976	Fig. 7 D, E
	<i>Ctenophthalmus savii</i> Jordan & Rothschild, 1921, ssp. (Abruzzo, Italy)	Fig. 7 F
	<i>Ctenophthalmus solutus solutus</i> Jordan & Rothschild, 1920	Fig. 7 G, H
	<i>Ctenophthalmus solutus nasutus</i> Beaucournu, Valle & Launay, 1989	Fig. 7 I, J
	<i>Ctenophthalmus ubayensis ubayensis</i> Lumaret & Lumaret, 1969	Fig. 7 K, L
	<i>Doratopsylla dasynema cuspis</i> Rothschild, 1915	Fig. 7 M, 8 A
	<i>Dinopsyllus djaensis</i> Beaucournu & Colyn, 1998	Fig. 8 B, C
	<i>Dinopsyllus ellobius</i> (Rothschild, 1905)	Fig. 8 D, E
	<i>Listropsylla prominens</i> Jordan, 1930	Fig. 8 F
	<i>Neotyphloceras crassispina</i> Rothschild, 1914	Fig. 8 G
	<i>Palaeopsylla cisalpina</i> Jordan & Rothschild, 1920	Fig. 8 H, I
	<i>Palaeopsylla kohauti</i> Dampf, 1911	Fig. 8 J, K
	<i>Palaeopsylla minor</i> (Dale, 1878)	Fig. 8 L, M
	<i>Palaeopsylla soricis</i> (Dale, 1878)	Fig. 8 N
	<i>Palaeopsylla soricis rosickyi</i> Smit, 1960	Fig. 8 O, 9 A
	<i>Palaeopsylla vallei</i> Beaucournu, 1979	Fig. 9 B, C
	<i>Rhadinopsylla integella</i> Jordan & Rothschild, 1921	Fig. 9 D, E
	<i>Rhadinopsylla isacantha</i> (Rothschild, 1907)	Fig. 9 F, G
	<i>Rhadinopsylla mesa</i> Jordan & Rothschild, 1920	Fig. 9 H
	<i>Rhadinopsylla pentacantha</i> (Rothschild, 1897)	Fig. 9 I, J
	<i>Stenoponia tripectinata</i> (Tiraboschi, 1902)	Fig. 9 K, L
Hystrichopsyllidae	<i>Atyphloceras nuperus</i> (Jordan, 1931)	Fig. 10 A, B
	<i>Hystrichopsylla orientalis orientalis</i> Smit, 1956	Fig. 10 C, D
	<i>Hystrichopsylla talpae alpina</i> Beaucournu & Launay, 1979	Fig. 10 E, F
	<i>Hystrichopsylla talpae talpae</i> (Curtis, 1826)	Fig. 10 G, H
	<i>Hystrichopsylla talpae</i> (Curtis, 1826) ssp. (Veneto, Italy)	Fig. 10 I, J
	<i>Hystrichopsylla talpae transalpina</i> Beaucournu, Launay & Valle, 1982	Fig. 10 K, L
	<i>Typhloceras favosus asunicus</i> Jordan, 1938	Fig. 10 M

Family	Species	Figure
	<i>Typhloceras poppei poppei</i> Wagner, 1903	Fig. 10 N, O
Ischnopsyllidae	<i>Araeopsylla gestroi</i> (Rothschild, 1906)	Fig. 11 A, B
	<i>Ischnopsyllus elongatus</i> (Curtis, 1832)	Fig. 11 C, D
	<i>Ischnopsyllus hexactenus</i> (Kolenati, 1856)	Fig. 11 E, F
	<i>Ischnopsyllus intermedius</i> (Rothschild, 1898)	Fig. 11 G
	<i>Ischnopsyllus octactenus</i> (Kolenati, 1856)	Fig. 11 H
	<i>Lagaropsylla sp.</i> (Yambio, South Sudan)	Fig. 11 I
	<i>Lagaropsylla sp.</i> (Yambio, South Sudan)	Fig. 11 J
	<i>Nycteridopsylla longiceps</i> Rothschild, 1908	Fig. 11 K
	<i>Nycteridopsylla pentactena</i> (Kolenati, 1856)	Fig. 11 L, M
	<i>Rhinolophopsylla unipectinata</i> (Taschenberg, 1880)	Fig. 11 N, O
Leptopsyllidae	<i>Amphipsylla sibirica sepiifera</i> Jordan & Rothschild, 1920	Fig. 12 A
	<i>Caenopsylla laptevi</i> Mikulin & Zagniborodova, 1958	Fig. 12 B
	<i>Frontopsylla frontalis frontalis</i> Rothschild, 1908	Fig. 12 C
	<i>Leptopsylla segnis</i> (Schonherr, 1811)	Fig. 12D, E
	<i>Leptopsylla taschenbergi calamana</i> Jordan, 1951	Fig. 12 F, G
	<i>Odontopsyllus quirosi episcopalis</i> Beaucornu & Gilot, 1975	Fig. 12 H, I
	<i>Peromyscopsylla bidentata bidentata</i> (Kolenati, 1953)	Fig. 12 J, K
	<i>Peromyscopsylla fallax</i> (Rothschild, 1909)	Fig. 12 L, M
	<i>Peromyscopsylla silvatica</i> (Meinert, 1896)	Fig. 12 N, O
Pulicidae	<i>Archaeopsylla erinacei</i> (Bouche, 1835)	Fig. 13 A, B
	<i>Ctenocephalides canis</i> (Curtis, 1826)	Fig. 13 C, D
	<i>Ctenocephalides felis felis</i> (Bouche, 1832)	Fig. 13 E, F
	<i>Ctenocephalides felis strongylus</i> (Jordan, 1925)	Fig. 13 G, H
	<i>Echidnophaga gallinacea</i> (Westwood, 1875)	Fig. 13 I, J
	<i>Echidnophaga murina</i> (Tiraboschi, 1903)	Fig. 13 K
	<i>Euhoplopsyllus glacialis affinis</i> (Baker, 1904)	Fig. 13 L, M
	<i>Parapulex echinatus</i> Smit, 1956	Fig. 13 N, O
	<i>Pariodontis riggenbachi riggenbachi</i> (Rothschild, 1904)	Fig. 14 A, B
	<i>Procaviopsylla isidis</i> (Rothschild, 1903)	Fig. 14 C, D
	<i>Pulex irritans</i> Linnaeus, 1758	Fig. 14 E, F
	<i>Synosternus cleopatrae pyramidis</i> (Rothschild, 1904)	Fig. 14 G, H
	<i>Spilopsyllus cuniculi</i> (Dale, 1878)	Fig. 14 I, J
	<i>Xenopsylla cheopis</i> (Rothschild, 1903)	Fig. 14 K, L
	<i>Xenopsylla gratiosa</i> Jordan & Rothschild, 1923	Fig. 14 M, N
Pygiopsyllidae	<i>Pagipsylla galliralli</i> (Smit, 1965)	Fig. 15 A, B
	<i>Pygiopsylla phiola</i> Smit, 1979	Fig. 15 C, D
Rhopalopsyllidae	<i>Delostichus phyllotis</i> Johnson, 1957	Fig. 16 A
	<i>Delostichus smiti</i> Jameson & Fulk, 1977	Fig. 16 B, C
	<i>Delostichus talis</i> (Jordan, 1936)	Fig. 16 D
	<i>Ectinorus chilensis</i> Lewis, 1976	Fig. 16 E, F
	<i>Parapsyllus longicornis</i> Enderlein, 1901	Fig. 16 G, H
	<i>Rhopalopsyllus lugubris</i> Jordan & Rothschild, 1908	Fig. 16 I, J
	<i>Tetrapsyllus corfidii</i> (Rothschild, 1904)	Fig. 16 K, L
	<i>Tetrapsyllus simulans</i> Jameson & Fulk, 1977	Fig. 16 M
	<i>Tetrapsyllus tantillus</i> (Jordan & Rothschild, 1923)	Fig. 16 N
Stephanocircidae	<i>Barreropsylla excelsa</i> Jordan, 1953	Fig. 17 A, B
	<i>Plocopsylla reigi</i> Beaucornu & Gallardo, 1978	Fig. 17 C, D
	<i>Sphinctopsylla ares</i> (Rothschild, 1911)	Fig. 17 E, F
Tungidae	<i>Tunga penetrans</i> Linnaeus, 1758	Fig. 18 A
Vermipsyllidae	<i>Chaetopsylla globiceps</i> (Taschenberg, 1880)	Fig. 19 A, B
	<i>Chaetopsylla homoea</i> Rothschild, 1906	Fig. 19 C
	<i>Chaetopsylla rothschildi</i> Kohaut, 1903	Fig. 19 D, E
	<i>Chaetopsylla trichosa</i> Kohaut, 1903	Fig. 19 F, G

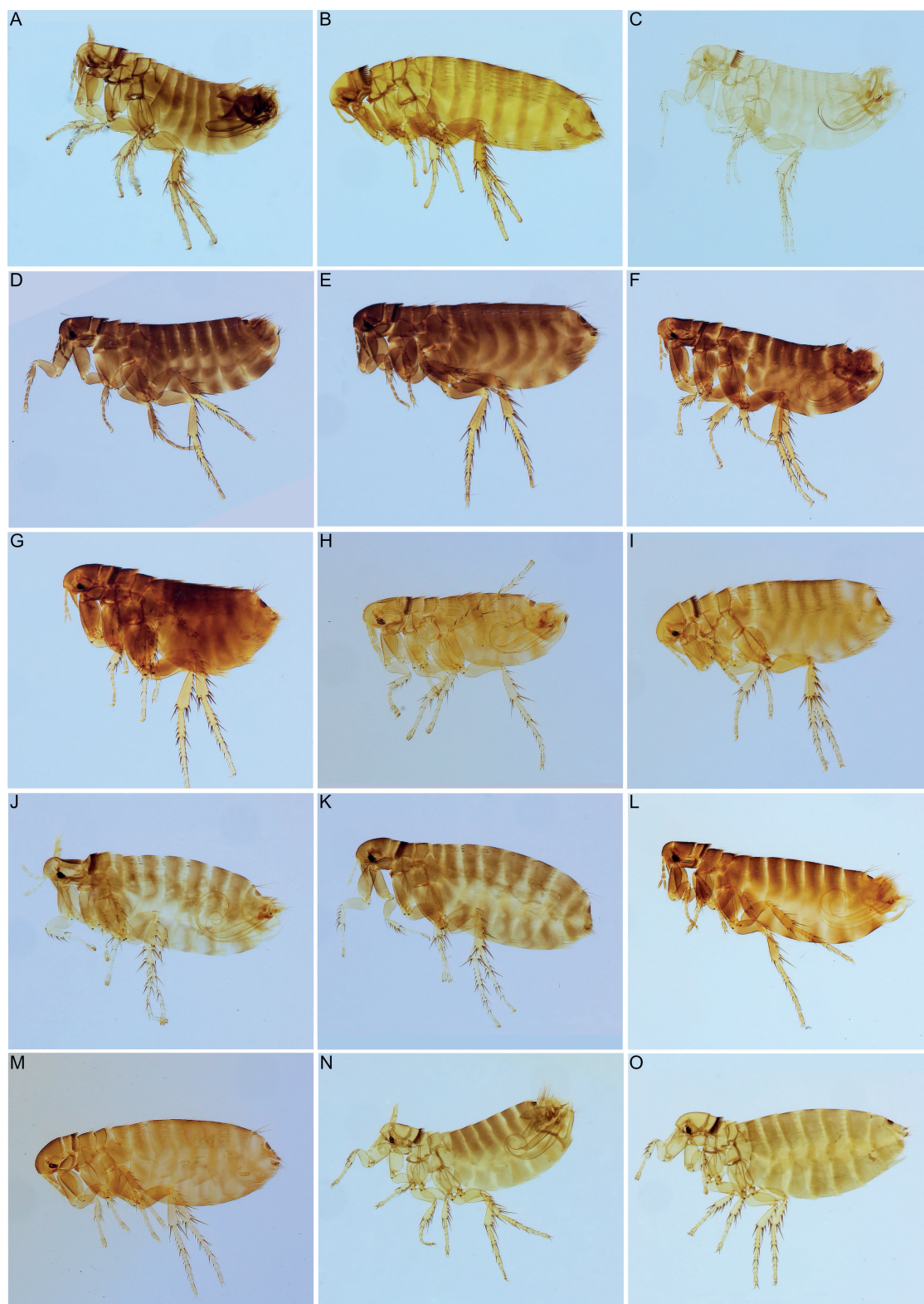


Fig. 1 – Ceratophyllidae, habitus in lateral view of microscope slide mounted specimens. **A**, *Amalareus arvicolae* (Ioff, 1948), male (Veneto, Giazza); **B**, *Amalareus penicilliger* (Grube, 1851), female (Piemonte Maritime Alps, Sambuco); **C**, *Callopsylla saxatilis* (Ioff et Argyropulo, 1934), male (Val d'Aosta, Cogne); **D-E**, *Ceratophyllus borealis* Rothschild, 1906, **D**, male, **E**, female (France, Col d'Ares); **F-G**, *Ceratophyllus chasteli* Beaucournu, Monnat & Launay, 1982, **F**, male (Corse, Lavezzi), **G**, female (Corse, Osani); **H-I**, *Ceratophyllus columbae* Gervais, 1844, **H**, male, **I**, female (Tuscany, Firenze); **J-K**, *Ceratophyllus fringillae* Walker, 1856, **J**, male, **K**, female (France, Liffre); **L-M**, *Ceratophyllus gallinae* (Schränk, 1803), **L**, male, **M**, female (Veneto, Pastrengo); **N-O**, *Ceratophyllus hirundinis* Curtis, 1826, **N**, male, **O**, female (Basilicata, Viggiano).

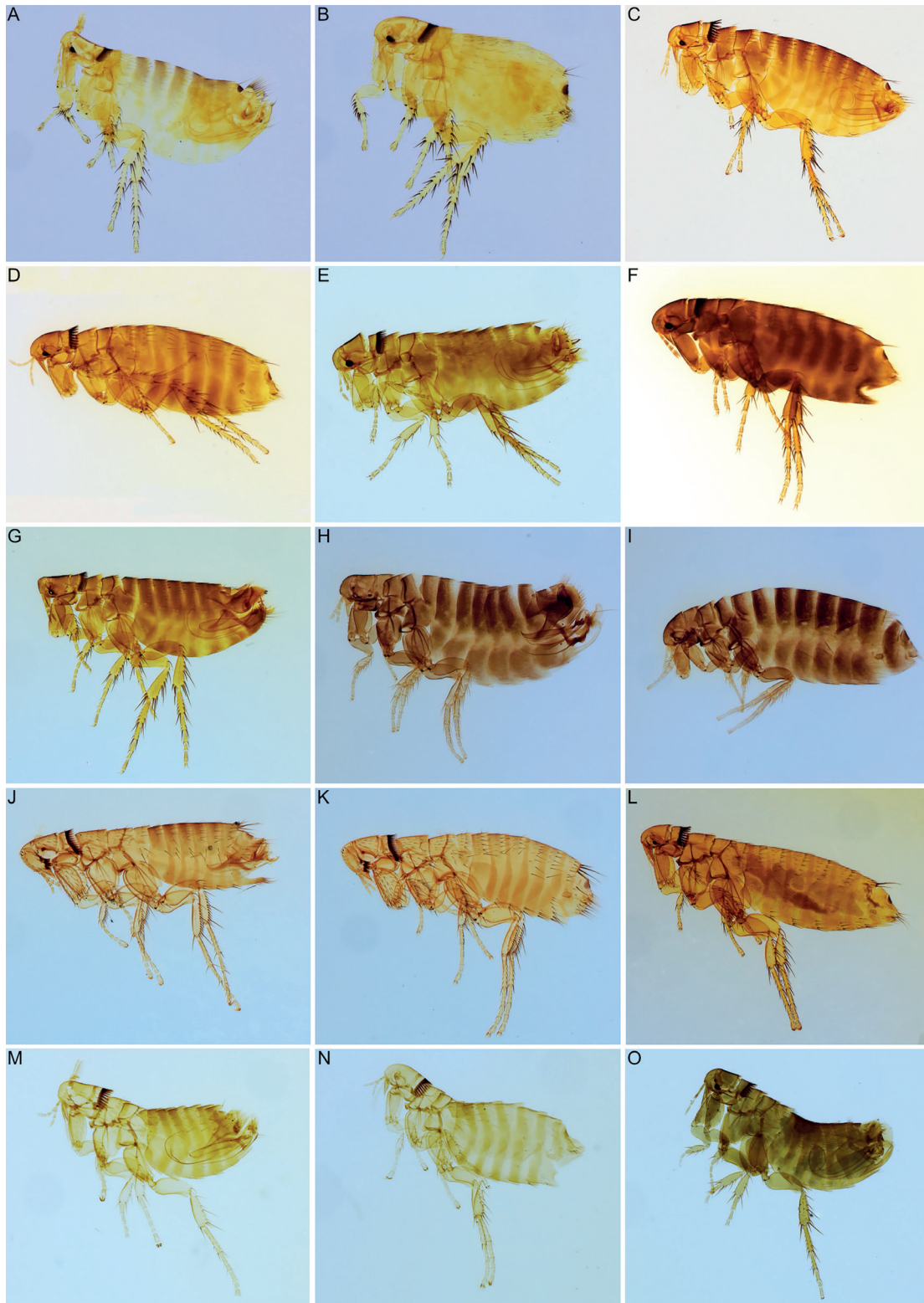


Fig. 2 – Ceratophyllidae, habitus in lateral view of microscope slide mounted specimens. **A-B**, *Ceratophyllus rusticus* Wagner, 1903, **A**, male, **B**, female (France, Saint-Paul-de-Vence); **C-D**, *Ceratophyllus sciurorum* (Schränk, 1803), **C**, male (Tuscany, Pentolina), **D**, female (Trentino Alto Adige, Fiaivè); **E-F**, *Dasypsyllus gallinulae* (Dale, 1878), **E**, male (Tuscany, Pistoia), **F**, female (Abruzzo, Colledara); **G-H**, *Glaciopsyllus antarcticus* Smit & Dunnet, 1962, **G**, male, **H**, female (Australian Antarctic territory, Ardery Island); **I**, *Libyastus* sp. Jordan, 1936, female (Republique Du Congo, Mbanza); **J-K**, *Myoxopsylla laverani* (Rothschild, 1911), **J**, male, **K** female (Abruzzo, Villetta Barrea); **L-M**, *Megabothris turbidus* (Rothschild, 1909), **L**, male (Basilicata, San Severino Lucano), **M**, female (Czech Republic, Filipov); **N-O**, *Nosopsyllus barbarus* (Jordan & Rothschild, 1912), **N**, male (Spain, Huelva), **O**, female (Sicily, Lampedusa).

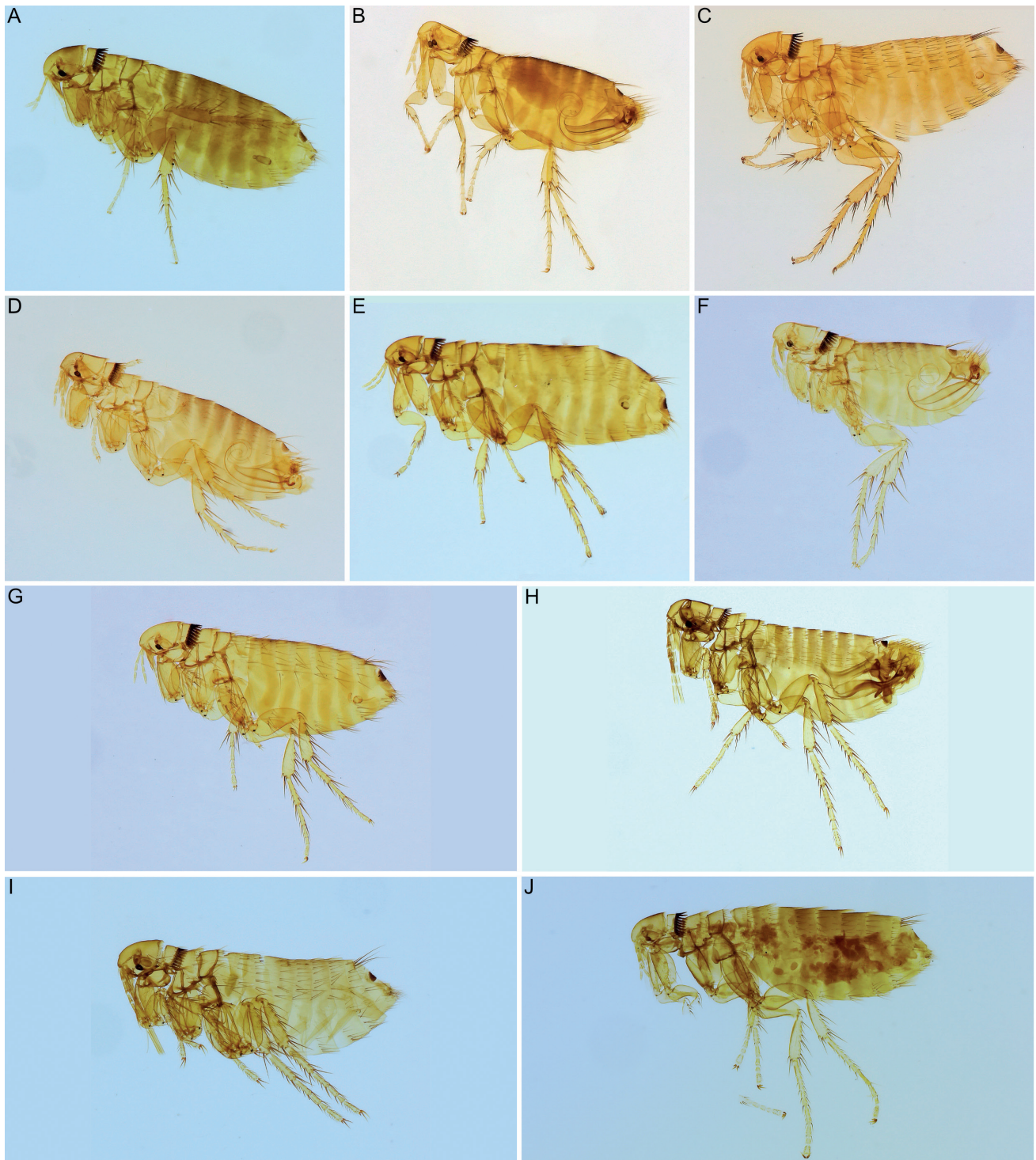


Fig. 3 – Ceratophyllidae, habitus in lateral view of microscope slide mounted specimens. **A-B**, *Nosopsyllus fasciatus* (Bosc, 1800), **A**, male (Trentino Alto Adige, Fontanazzo), **B**, female (Lazio, Roma); **C-D**, *Nosopsyllus londiniensis londiniensis* (Rothschild, 1903), **C**, male, **D**, female (Morocco, Vallée du Sous, Agadir); **E-F**, *Paraceras melis* (Walker, 1856), **E**, male, **F**, female (Turkey, Izmir); **G**, *Tarsopsylla octodecimentata* (Kolenati, 1863), female (Veneto, Padova).

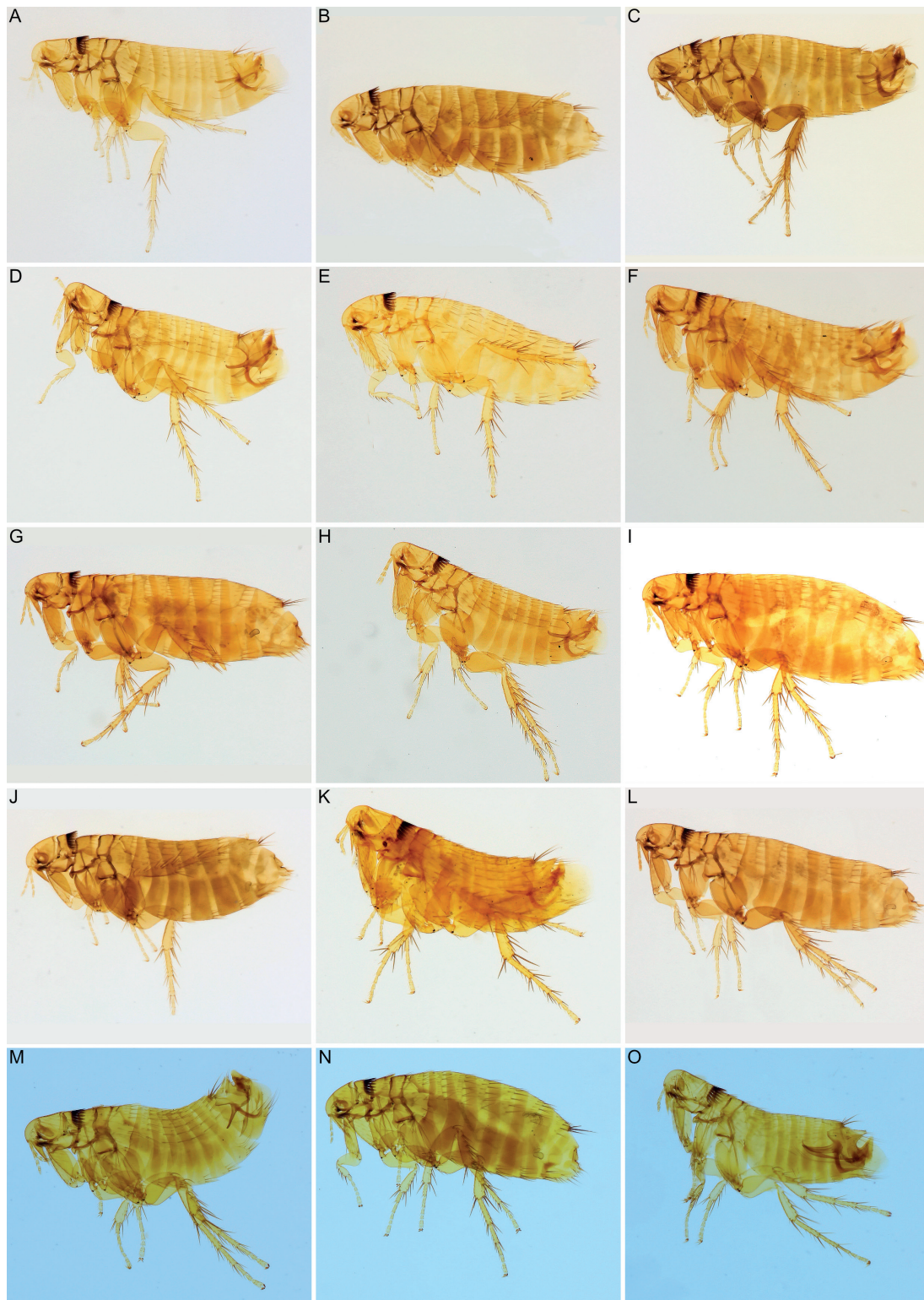


Fig. 4 – Ctenophthalmidae, habitus in lateral view of microscope slide mounted specimens. **A-B**, *Ctenophthalmus agyrtes agyrtes* (Heller, 1896), **A**, male, **B**, female (Czech Republic, Filipov); **C**, *Ctenophthalmus agyrtes culter* Beaucournu, Valle & Launay, 1981, male (Calabria, Santo Stefano d' Aspromonte); **D-E**, *Ctenophthalmus agyrtes impavidus* Jordan, 1928, **D**, male, **E**, female (France, Tavers); **F-G**, *Ctenophthalmus agyrtes provincialis* Rothschild, 1910, **F**, male (France, Molines-en-Queyras), **G**, female (France, Ville Vieille); **H-I**, *Ctenophthalmus agyrtes sardiniensis* Ioff, 1928, **H**, male, **I**, female (Lazio, Monti Cimini); **J**, *Ctenophthalmus agyrtes* (Heller, 1896) ssp., female (Czech Republic, Česká Kamenice); **K-L**, *Ctenophthalmus agyrtes verbanus* Jordan & Rothschild, 1920, **K**, male, **L**, female (Lombardia, Gorno); **M-N**, *Ctenophthalmus andorrensis* Smit, 1960, **M**, male, **N**, female (Spain, Albarracin); **O**, *Ctenophthalmus apertus apertus* Jordan & Rothschild, 1921, male (France, Blancefort).

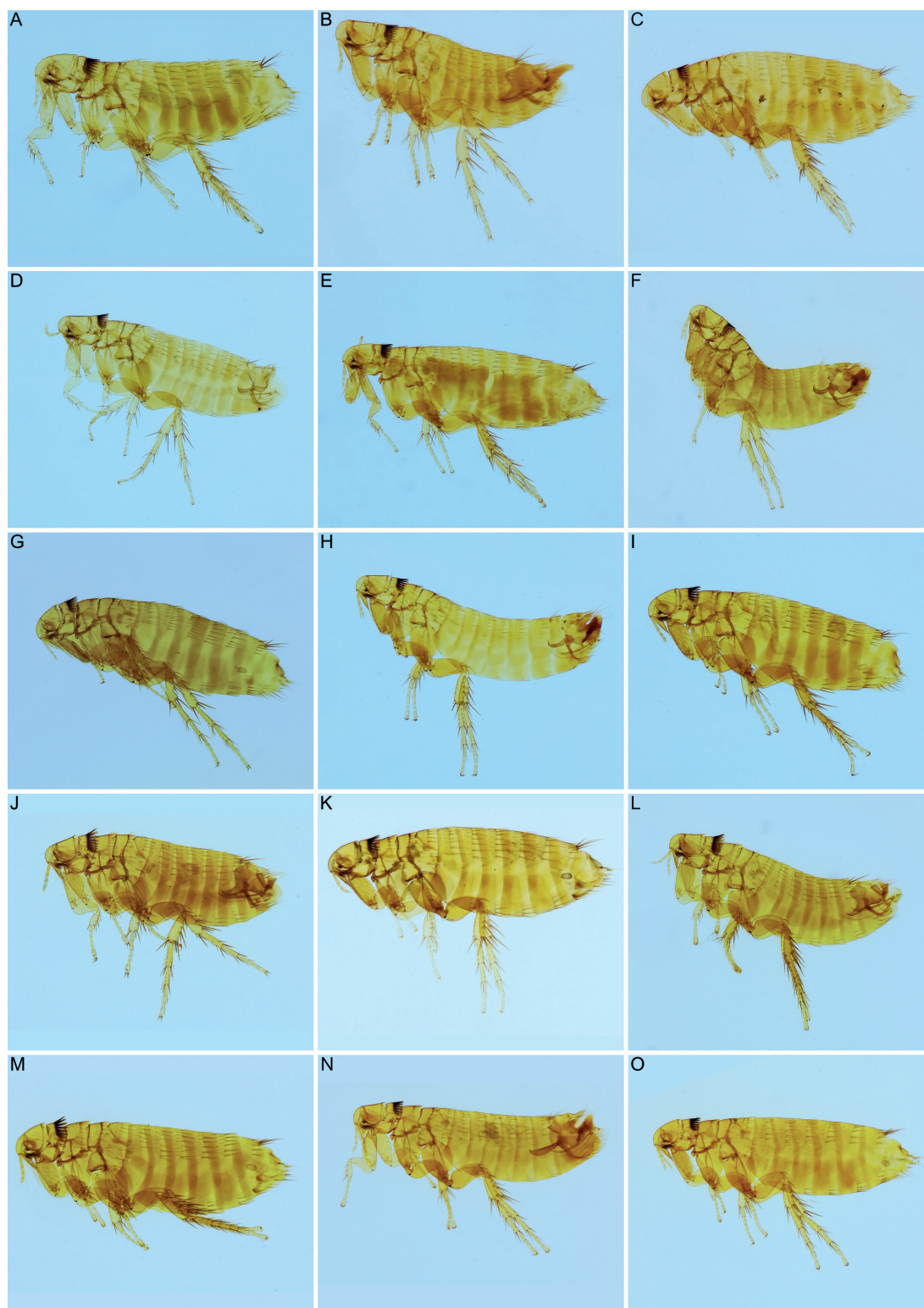


Fig. 5 – Ctenophthalmidae, habitus in lateral view of microscope slide mounted specimens. **A**, *Ctenophthalmus apertus apertus* Jordan & Rothschild, 1921, female (Spain, Villanueva de Sigena); **B-C**, *Ctenophthalmus assimilis assimilis* (Taschenberg, 1880), **B**, male, **C**, female (France, Gonsans); **D-E**, *Ctenophthalmus baeticus arvernus* Jordan, 1931, **D**, male (Andorra, Arinsal), **E**, female (Spain, Arenas de Cabrales); **F-G**, *Ctenophthalmus bisoctodentatus bisoctodentatus* Kolenati, 1863, **F**, male (Friuli, Duino), **G**, female (Trentino Alto Adige, Borgo Valsugana); **H-I**, *Ctenophthalmus bisoctodentatus certus* Beaucournu, 1979, **H**, male, **I**, female (Lombardy, Gorno); **J-K**, *Ctenophthalmus congener congener* Rothschild, 1907, **J**, male (France, Le Villaret), **K**, female (Lombardy, Gorno); **L-M**, *Ctenophthalmus congener grulichii* Beaucournu, 1964, **L**, male, **M**, female (Piemonte, Castelmagno); **N-O**, *Ctenophthalmus egregius egregius* Peus, 1964, **N**, male, **O**, female (Lazio, Roma).

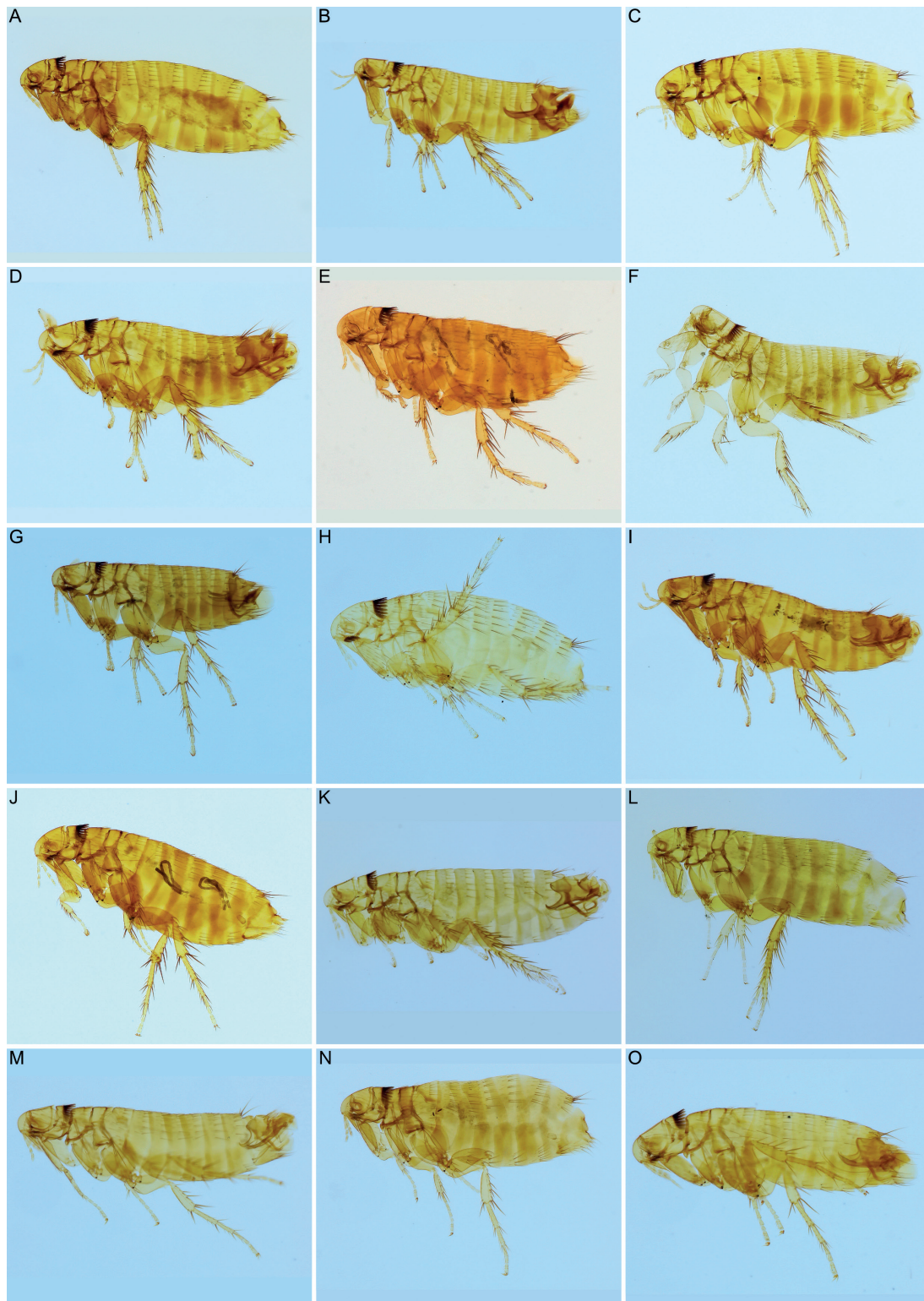


Fig. 6 – Ctenophthalmidae, habitus in lateral view of microscope slide mounted specimens. **A**, *Ctenophthalmus egregius garganus* Beaucournu & Grulich, 1976, female (Puglia, Monte Gargano); **B-C**, *Ctenophthalmus niethammeri* Beaucournu, Valle & Launay, 1981, **B**, male, **C**, female (Calabria, San Giovanni in Fiore); **D-E**, *Ctenophthalmus nivalis nivalis* Rothschild, 1909, **D**, male, **E**, female (Val d’Aosta, Breuil); **F**, *Ctenophthalmus nivalis helveticus* Smit, 1963, male (Piemonte, Biella); **G-H**, *Ctenophthalmus nobilis nobilis* (Rothschild, 1898), **G**, male (France, Izeaux), **H**, female (Switzerland, Vaud-Saint George); **I-J**, *Ctenophthalmus orphilus orphilus* Jordan & Rothschild, 1923, **I**, male, **J**, female (Switzerland, Julier Pass); **K-L**, *Ctenophthalmus orphilus dolomiticus* Jordan & Rothschild, 1923, **K**, male, **L**, female (Veneto, Boscochiesanuova); **M-N**, *Ctenophthalmus russulae russulae* Jordan & Rothschild, 1912, **M**, male, **N**, female (Spain, Ibiza); **O**, *Ctenophthalmus russulae galloibericus* Beaucournu & Lumaret, 1972, male (Spain, Medes Islands).

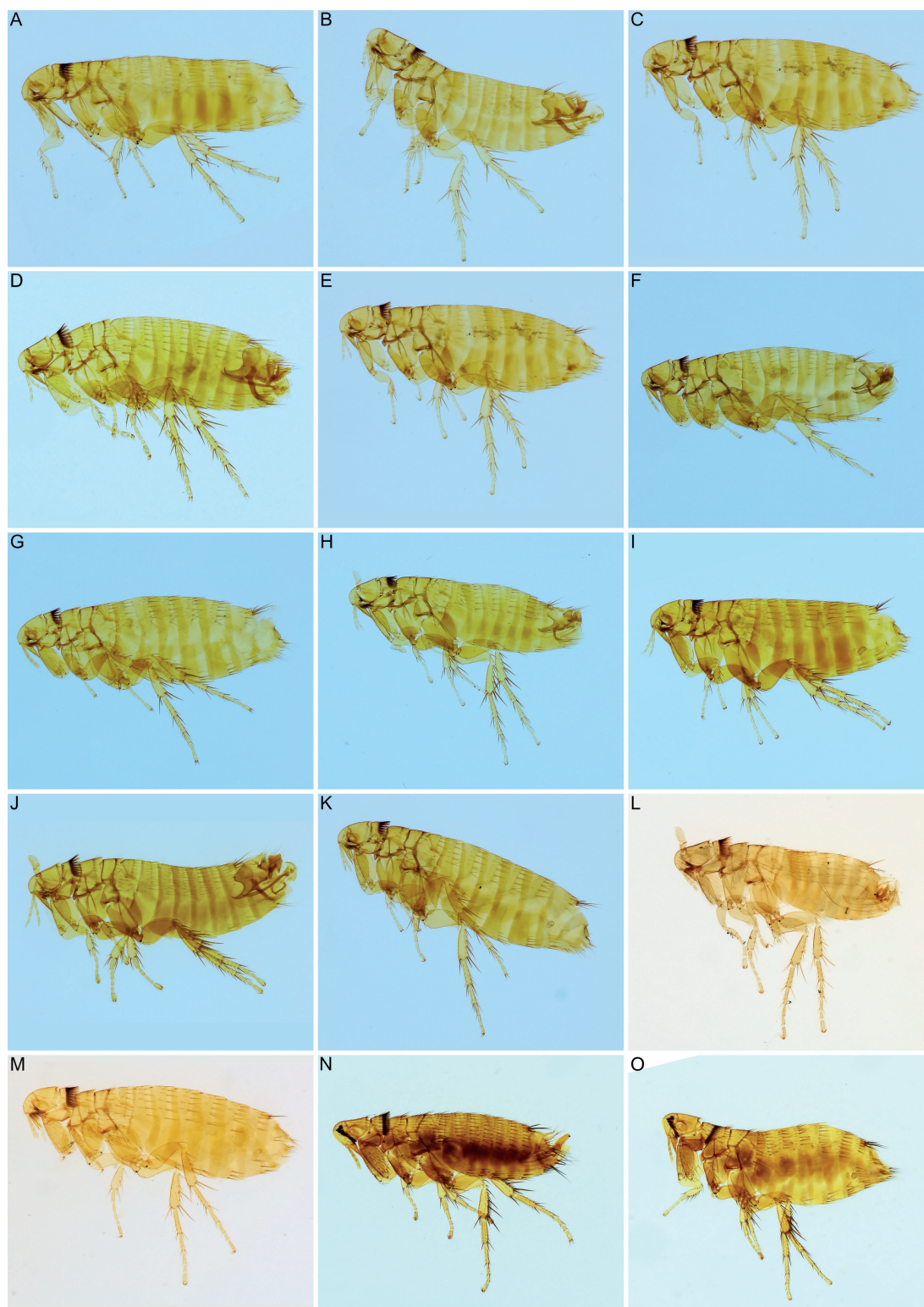


Fig. 7 – Ctenophthalmidae, habitus in lateral view of microscope slide mounted specimens. **A**, *Ctenophthalmus russulae galloibericus* Beaucournu & Lumaret, 1972, female (Spain, Medes Islands); **B-C**, *Ctenophthalmus savii savii* Jordan & Rothschild, 1921, **B**, male, **C**, female (Calabria, Morano Calabro); **D-E**, *Ctenophthalmus savii matilei* Beaucournu & Grulich, 1976, **D**, male, **E**, female (Lazio, Flamignano); **F-G**, *Ctenophthalmus solutus solutus* Jordan & Rothschild, 1920, **F**, male, **G**, female (Lazio, Monti Cimini); **H-I**, *Ctenophthalmus solutus nasutus* Beaucournu, Valle & Launay, 1989, **H**, male, **I**, female (Calabria, San Giovanni in Fiore); **J-K**, *Ctenophthalmus ubayensis ubayensis* Lumaret & Lumaret, 1969, **J**, male (Piemonte, Castelmagno), **K**, female (France, Lac Egorgeou); **L-M**, *Doratopsylla dasyncema cuspis* Rothschild, 1915, **L**, male, **M**, female (Calabria, Santo Stefano d'Aspromonte); **N**, *Dinopsyllus djaensis* Beaucournu & Colyn, 1998, male (Camerun, Dja faunal reserve); **O**, *Dinopsyllus ellobius* (Rothschild, 1905), male (South Africa, Pietermaritzburg).

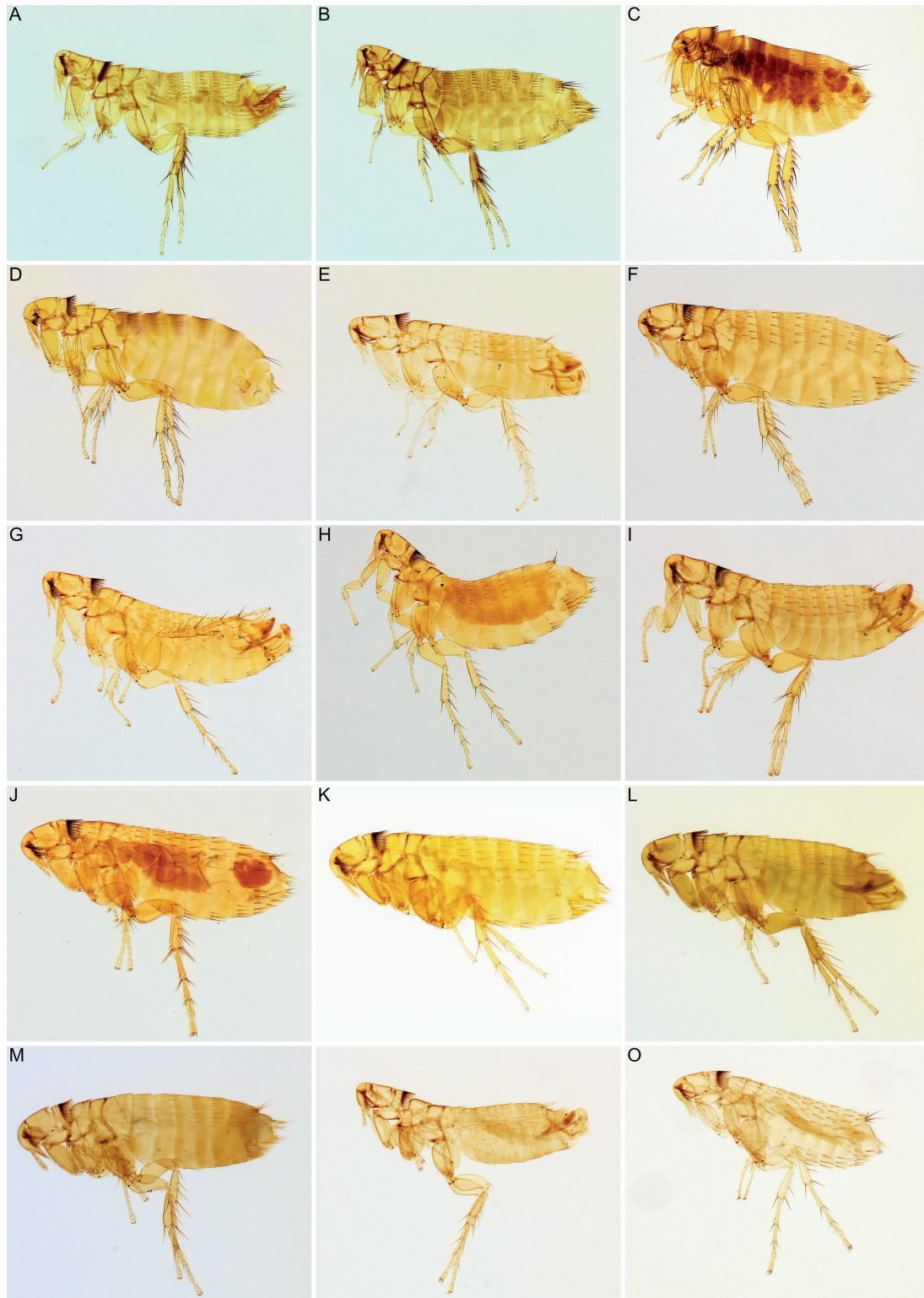


Fig. 8 – Ctenophthalmidae, habitus in lateral view of microscope slide mounted specimens. **A**, *Dinopsyllus ellobius* (Rothschild, 1905), female (South Africa, Pietermaritzburg); **B**, *Listropsylla prominens* Jordan, 1930, female (South Africa, Pietermaritzburg); **C**, *Neotyphloceras crassispina* Rothschild, 1914, female (Chile, Fray Jorge national Park); **D-E**, *Palaeopsylla cisalpina* Jordan & Rothschild, 1920, **D**, male (Veneto, Boscochiesanuova), **E**, female (Valle d’Aosta, Breuil); **F-G**, *Palaeopsylla kohauti* Dampf, 1911, **F**, male, **G**, female (Czech Republic, Klèc); **H-I**, *Palaeopsylla minor* (Dale, 1878), **H**, male (France, Vaulnaveys), **I**, female (France, Strasbourg); **L**, *Palaeopsylla soricis* (Dale, 1878), female (Trentino Alto Adige, Bolzano); **M-N**, *Palaeopsylla soricis rosickyi* Smit, 1960, **M**, male, **N**, female (Calabria, Santo Stefano d’Aspromonte); **O**, *Palaeopsylla vallei* Beaucournu, 1979, male (Calabria, Morano Calabro).

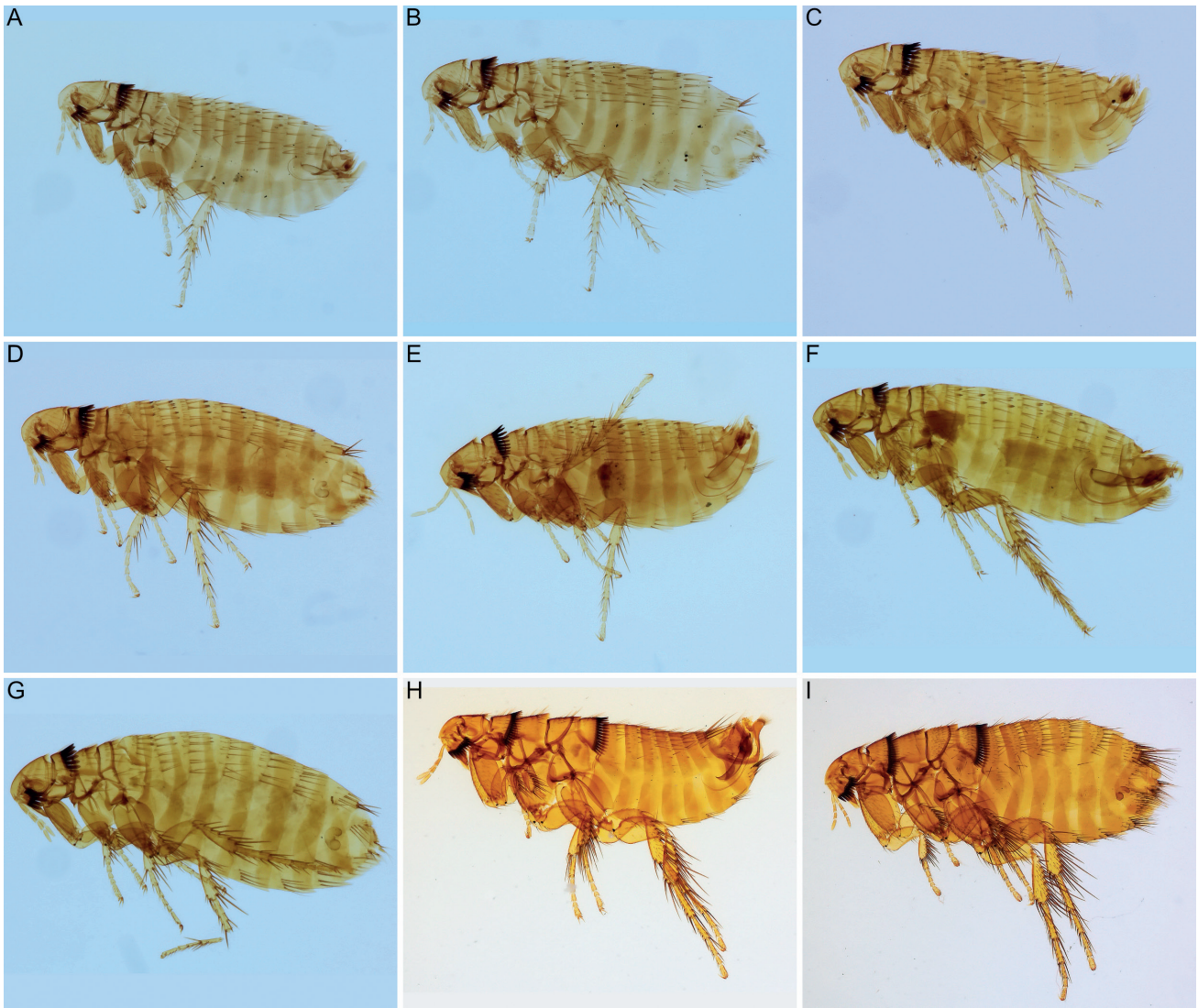


Fig. 9 – Ctenophthalmidae, habitus in lateral view of microscope slide mounted specimens. **A**, *Palaeopsylla vallei* Beaucournu, 1979, female (Calabria, Morano Calabro); **B-C**, *Rhadinopsylla integella* Jordan & Rothschild, 1921, **B**, male, **C**, female (Abruzzo, Assergi); **D-E**, *Rhadinopsylla isacantha* (Rothschild, 1907), **D**, male (France, Mazaye), **E**, female (Lazio, Monti Cimini); **F**, *Rhadinopsylla mesa* Jordan & Rothschild, 1920, male (Piemonte, Castelmagno); **G-H**, *Rhadinopsylla pentacantha* (Rothschild, 1897), **G**, male, **H**, female (Abruzzo, Rocca di Cambio); **I-J**, *Stenoponia tripectinata* (Tiraboschi, 1902), **I**, male, **J**, female (Spain, Punta del Cebo).

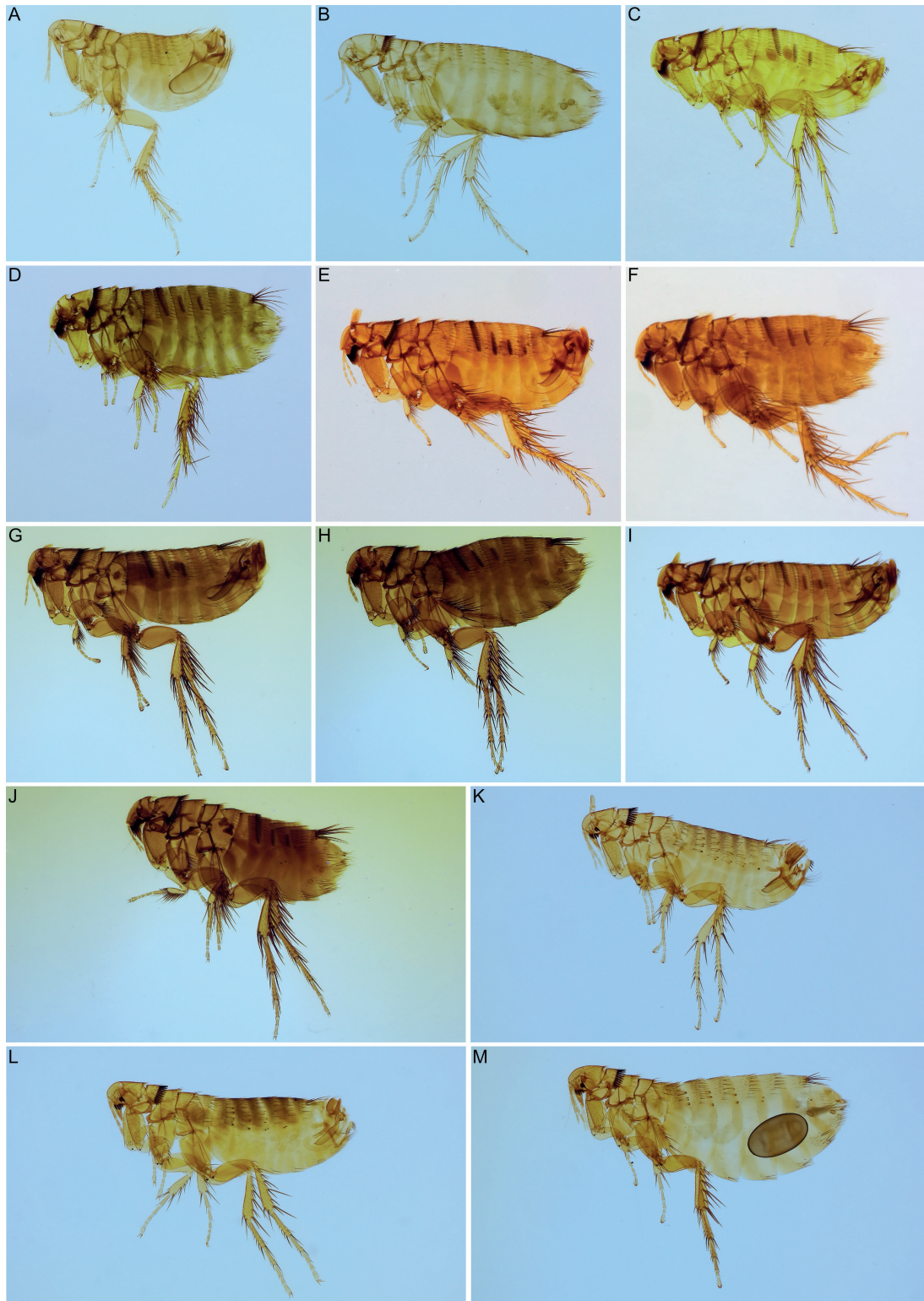


Fig. 10 – Hystrichopsyllidae, habitus in lateral view of microscope slide mounted specimens. **A-B**, *Atyphloceras nuperus* (Jordan, 1931), **A**, male (Veneto, Verona), **B**, female (Veneto, Monti Lessini); **C-D**, *Hystrichopsylla orientalis orientalis* Smit, 1956, **C**, male, **D**, female (Poland, Białowieża); **E-F**, *Hystrichopsylla talpae alpina* Beaucournu & Launay, 1979 **E**, male (France, Saint Vêran), **F**, female (paratype) (France, Venanson); **G-H**, *Hystrichopsylla talpae talpae* (Curtis, 1826), **G**, male, **H**, female (Piemonte, Valle dell’Orco); **I-J**, *Hystrichopsylla talpae transalpina* Beaucournu, Launay & Valle, 1982, **I**, male (Lazio, Monti Cimini), **J**, female (Lazio, Nemi); **K**, *Typhloceras favosus asunicus* Jordan, 1938, male (Sardegna, Sant’Antioco); **L-M**, *Typhloceras poppei poppei* Wagner, 1903, **L**, male (Lazio, Roma), **M**, female (Sardegna, Sant’Antioco).

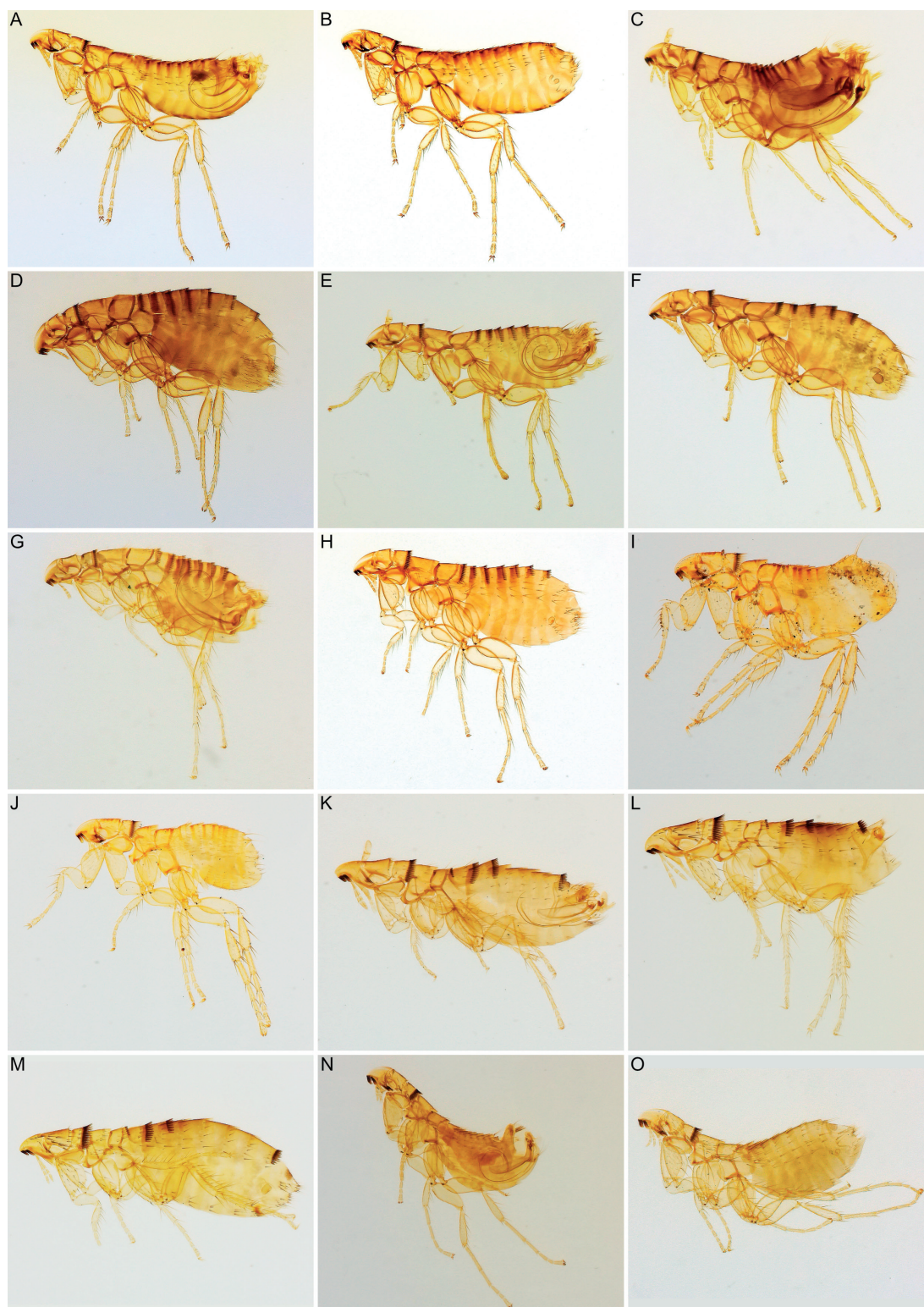


Fig. 11 – Ischnopsyllidae, habitus in lateral view of microscope slide mounted specimens. **A-B**, *Araeopsylla gestroi* (Rothschild, 1906), **A**, male, **B**, female (Lazio, Roma); **C-D**, *Ischnopsyllus elongatus* (Curtis, 1832), **C**, male, **D**, female (Tuscany, Pisa); **E-F**, *Ischnopsyllus hexactenus* (Kolenati, 1856), **E**, male (Lazio, Cittareale), **F**, female (Switzerland, Col de Bretolet); **G**, *Ischnopsyllus intermedius* (Rothschild, 1898), male (Piemonte, Domodossola); **H**, *Ischnopsyllus octactenus* (Kolenati, 1856), female (Umbria, Spoleto); **I**, *Lagaropsylla* sp., female (South Sudan, Yambio); **J**, *Lagaropsylla* sp., female (South Sudan, Yambio); **K**, *Nycteridopsylla longiceps* Rothschild, 1908, male (Tuscany, Pian di Novello); **L-M**, *Nycteridopsylla pentactena* (Kolenati, 1856), **L**, male, **M**, female (Tuscany, Pian di Novello); **N-O**, *Rhinolophopsylla unipunctinata* (Taschenberg, 1880), **N**, male (Calabria, Rossano), **O**, female (Sardegna, Tortoli).



Fig. 12 – Leptopsyllidae, habitus in lateral view of microscope slide mounted specimens. **A**, *Amphipsylla sibirica sepifera* Jordan & Rothschild, 1920, male (Val d'Aosta, Cogne); **B**, *Caenopsylla laptevi* Mikulin & Zagniborodova, 1958, male (Jordan, Dana); **C**, *Frontopsylla frontalis frontalis* Rothschild, 1908, male (Greece, Mount Parnassos); **D-E**, *Leptopsylla segnis* (Schonherr, 1811), **D**, male, **E**, female (Tuscany, Pentolina); **F-G**, *Leptopsylla taschenbergi calamana* Jordan, 1951 **F**, male (Potenza, San Severino Lucano), **G**, female (Campania, Ottaviano); **H-I**, *Odontopsyllus quirosi episcopalis* Beaucornu & Gilot, 1975, **H**, male, **I**, female (France, Orange); **J-K**, *Peromyscopsylla bidentata bidentata* (Kolenati, 1953), **J**, male (Veneto, Monti Lessini), **K**, female (Trentino Alto Adige, Trento); **L-M**, *Peromyscopsylla fallax* (Rothschild, 1909), **L**, male (Veneto, Verona), **M**, female (Potenza, San Severino Lucano); **N-O**, *Peromyscopsylla silvatica* (Meinert, 1896), **N**, male, **O**, female (Czech Republic, Litvínov).

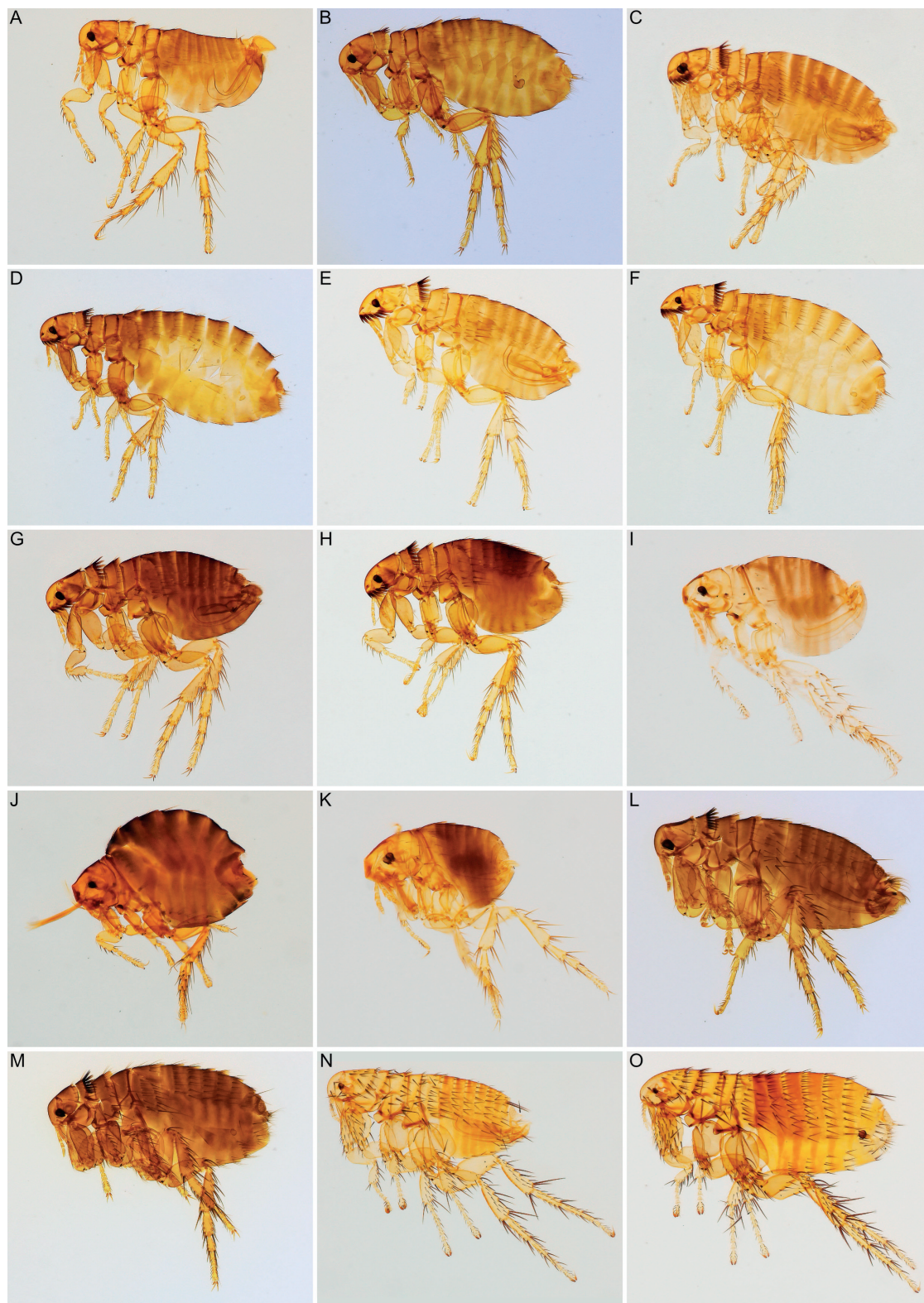


Fig. 13 – Pulicidae, habitus in lateral view of microscope slide mounted specimens. **A-B**, *Archaeopsylla erinacei* (Bouche, 1835), **A**, male (Sardegna, Monte Arci), **B**, female (Lazio, Roma); **C-D**, *Ctenocephalides canis* (Curtis, 1826), **C**, male, **D**, female (Basilicata, Potenza, Viggiano); **E-F**, *Ctenocephalides felis felis* (Bouche, 1832), **E**, male, **F**, female (Lazio, Roma); **G-H**, *Ctenocephalides felis strongylus* (Jordan, 1925), **G**, male, **H**, female (République du Congo, Kotwa); **I-J**, *Echidnophaga gallinacea* (Westwood, 1875), **I**, male, **J**, female (Zimbabwe); **K**, *Echidnophaga murina* (Tiraboschi, 1903), male (Spain, Ibiza); **L-M**, *Euchoptopsyllus glacialis affinis* (Baker, 1904), **L**, male, **M**, female (Piemonte, Carmagnola); **N-O**, *Parapulex echinatus* Smit, 1956, **N**, male, **O**, female (Ethiopia, Churchura).

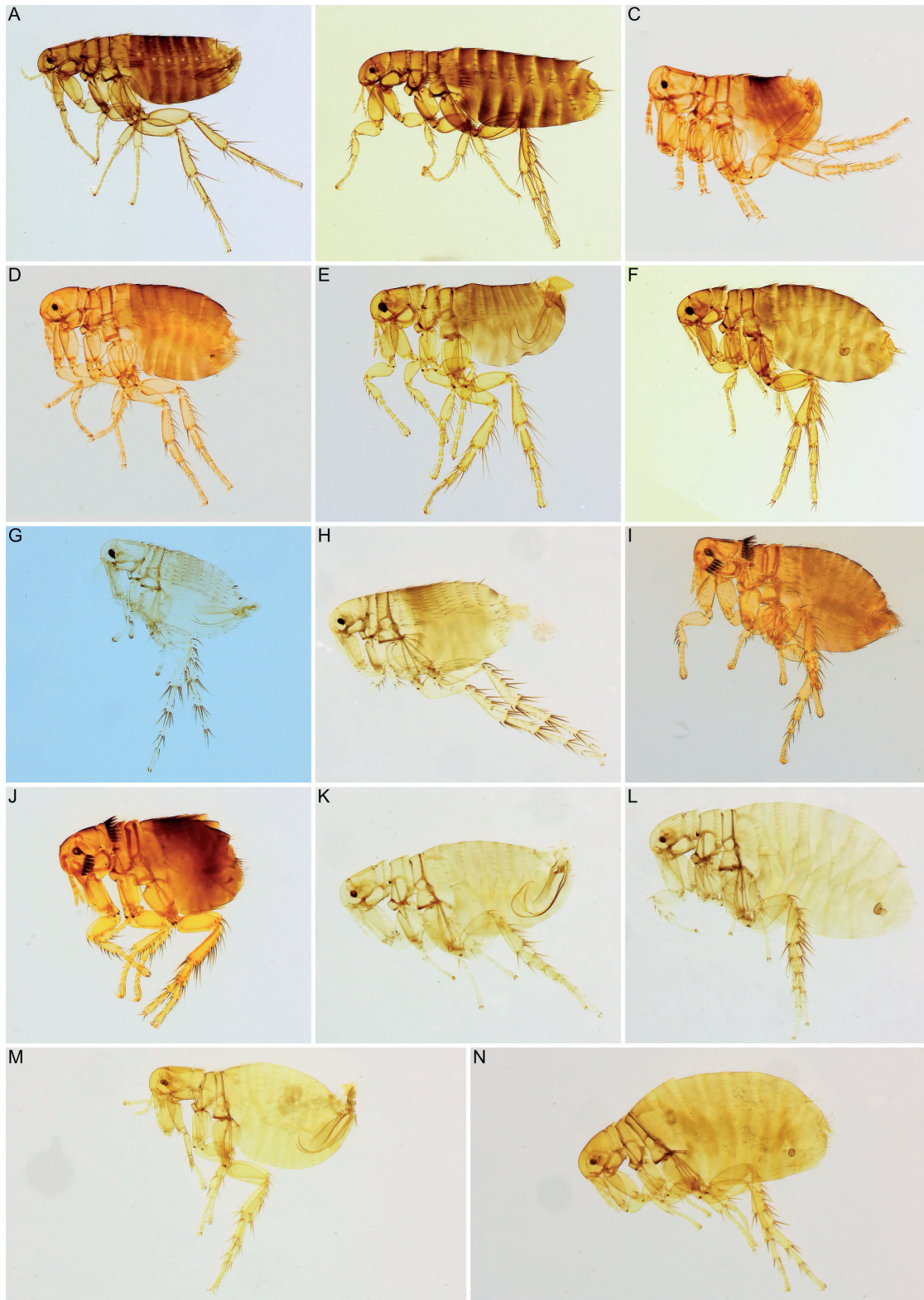


Fig. 14 – Pulicidae, habitus in lateral view of microscope slide mounted specimens. **A-B**, *Pariodontis riggenbachii riggenbachii* (Rothschild, 1904), **A**, male Rwanda, Butare), **B**, female (South Africa, Pretoria); **C-D**, *Procaviopsylla isidis* (Rothschild, 1903), **C**, male, **D**, female (Kenya, Kedong Valley); **E-F**, *Pulex irritans* Linnaeus, 1758, **E**, male, **F**, female (Jordan, Dana); **G-H**, *Synosternus cleopatrae pyramidis* (Rothschild, 1904), **G**, male, **H**, female (Mauritania, Tagant); **I-J**, *Spilopsyllus cuniculi* (Dale, 1878), **I**, male (Tuscany, Capraia Island), **J**, female (Lazio, Roma); **K-L**, *Xenopsylla cheopis* (Rothschild, 1903), **K**, male, **L**, female (Iran, Rasht); **M-N**, *Xenopsylla gratiosa* Jordan & Rothschild, 1923, **M**, male, **N**, female (Tunisia, Zembra Island).



Fig. 15 – Pygiopsyllidae, habitus in lateral view of microscope slide mounted specimens. **A-B**, *Pagipsylla galliralli* (Smit, 1965), **A**, male, **B**, female (New Zealand, Snares Island); **C-D**, *Pygiopsylla phiola* Smit, 1979, **C**, male, **D**, female (Queensland, Brookfield).

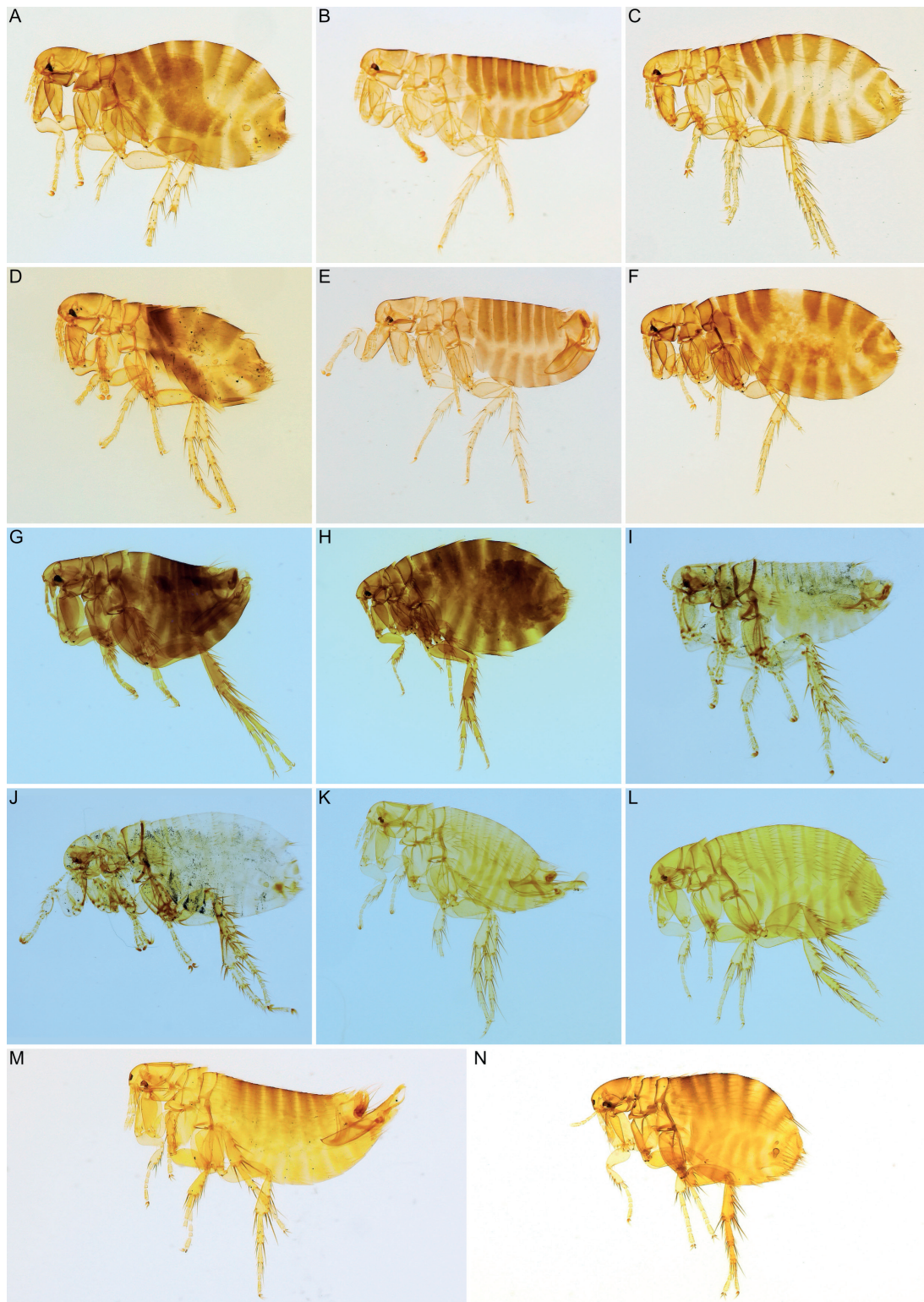


Fig. 16 – Rhopalopsyllidae, habitus in lateral view of microscope slide mounted specimens. **A**, *Delostichus phyllotis* Johnson, 1957, female (Chile, Fray Jorge National Park); **B-C**, *Delostichus smiti* Jameson & Fulk, 1977, **B**, male, **C**, female (Chile, Fray Jorge National Park); **D**, *Delostichus talis* (Jordan, 1936), female (Chile, Fray Jorge National Park); **E-F**, *Ectinorus chilensis* Lewis, 1976, **E**, male, **F**, female (Chile, Fray Jorge National Park); **G-H**, *Parapsyllus longicornis* Enderlein, 1901, **G**, male, **H**, female (New Zealand, Taylors Mistake); **I-J**, *Rhopalopsyllus lugubris* Jordan & Rothschild, 1908, **I**, male, **J**, female (Guyana, Marlissa); **K-L**, *Tetrapsyllus corfidii* (Rothschild, 1904), **K**, male, **L**, female (Chile, Fray Jorge National Park); **M**, *Tetrapsyllus simulans* Jameson & Fulk, 1977, male (Chile, Fray Jorge National Park); **N**, *Tetrapsyllus tantillus* (Jordan & Rothschild, 1923), female (Chile, Fray Jorge National Park).

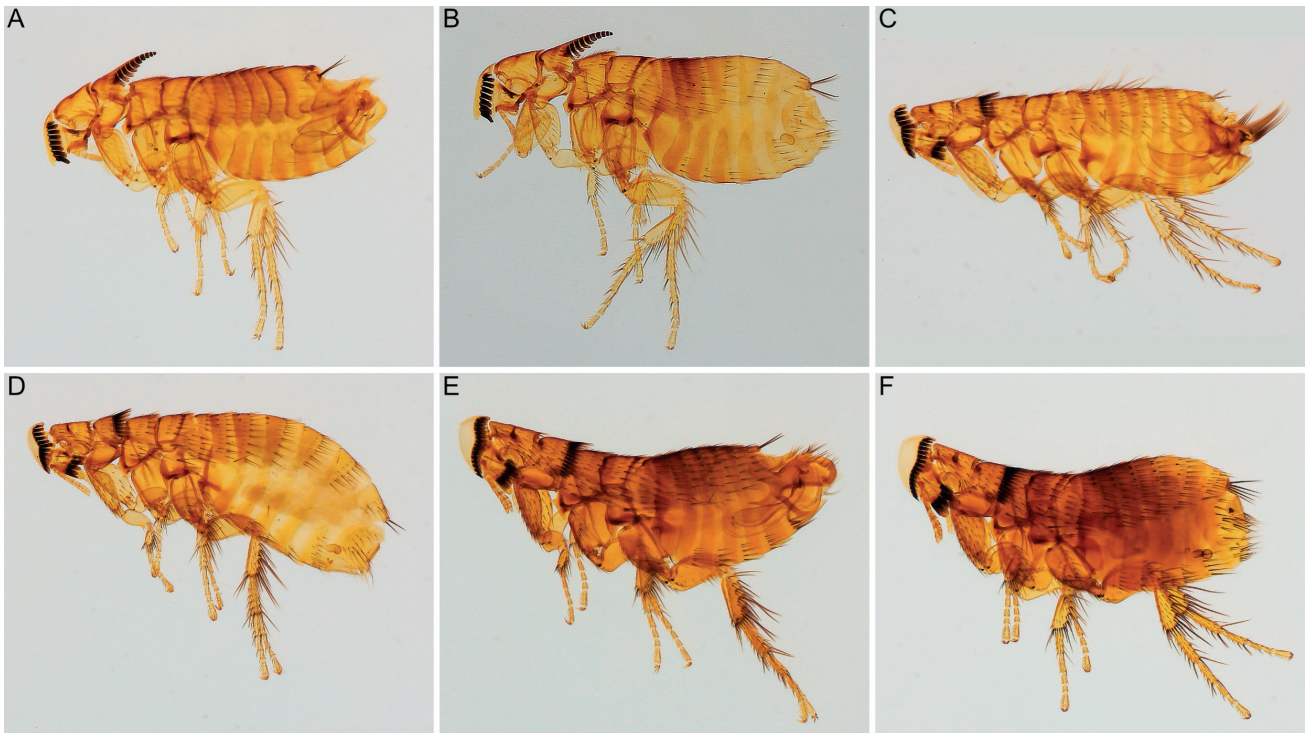


Fig. 17 – Stephanocircidae, habitus in lateral view of microscope slide mounted specimens. **A-B**, *Barreropsylla excelsa* Jordan, 1953, **A**, male, **B**, female (Argentina, Entre Lagos); **C-D**, *Plocopsylla reigi* Beaucournu & Gallardo, 1978, **C**, male, **D**, female (Chile, Malleco); **E-F**, *Sphinctopsylla ares* (Rothschild, 1911), **E**, male, **F**, female (Chile, Valdivia).



Fig. 18 – Tungidae, habitus in lateral view of microscope slide mounted specimens. **A**, *Tunga penetrans* Linnaeus, 1758, female (Republic of the Congo, Odzala-Kokoua National Park).



Fig. 19 – Vermipsyllidae, habitus in lateral view of microscope slide mounted specimens. **A-B**, *Chaetopsylla globiceps* (Taschenberg, 1880), **A**, male, **B**, female (France, Fontenoy); **C**, *Chaetopsylla homoea* Rothschild, 1906, male (Val d'Aosta, Parco Nazionale del Gran Paradiso); **D-E**, *Chaetopsylla rothschildi* Kohaut, 1903, **D**, male (France, Villefranche-de-Lauragais), **E**, female (France, Tonneins). **F-G**, *Chaetopsylla trichosa* Kohaut, 1903, **F**, male (Piemonte, Cumiana), **G**, female (Veneto, Monti Lessini).

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