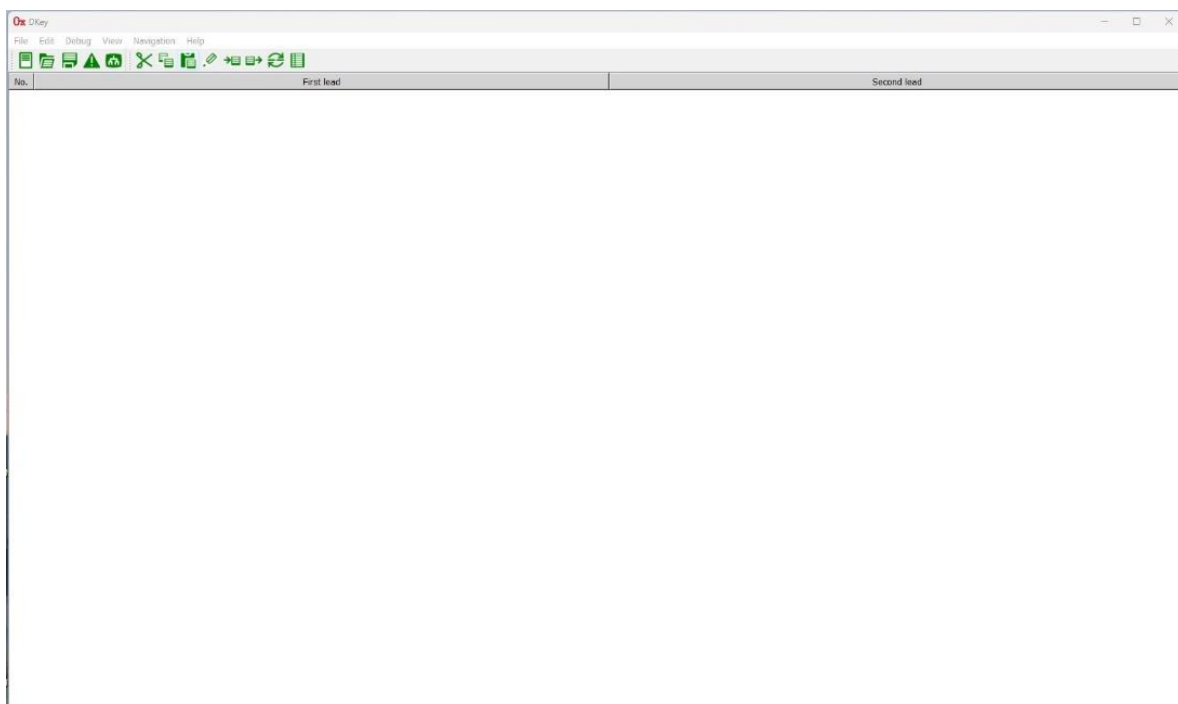


SLX. ONLINE PICTORIAL DICHOTOMOUS KEY

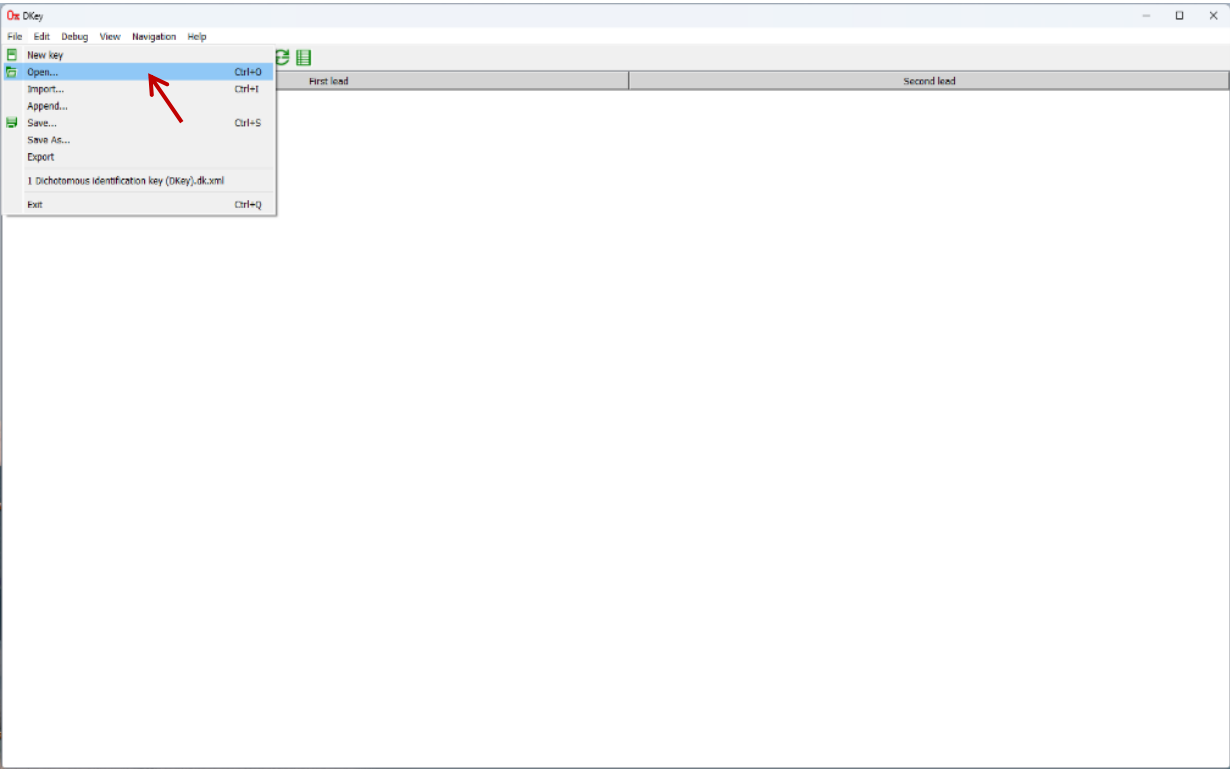
In this study, we created a software-assisted pictorial dichotomous key to aid in the species-level sand fly identification. This key provides a straightforward method for identifying various subgenera and species of *Phlebotomus* sand flies and is available in an interactive HTML format. Developed using the DKey software ¹, which is licensed under the GNU General Public License version 3, this tool is free to download and use. Taxonomic experts can use it to create keys, while users of printed keys can benefit from its user-friendly features. The source software file is available at <https://github.com/DrawWing/DKey>. The key comprises a series of consecutively numbered couplets, each with two parts called leads and a reference at the end. The reference can be either a number pointing to another couplet or text indicating a species or taxonomic group. References can be either "pointers" or "endpoints."

The identification process begins at couplet number one and progresses stepwise. The user reads both leads at each step and selects the one that best matches the specimen. If a selected lead is associated with a pointer, the user goes to the couplet with the number the pointer indicates. Identification concludes when a lead reaches an endpoint. The software displays hypertext-linked outputs, enhancing identification speed and ease. It is user-friendly, minimizing identification time by eliminating the need to flip pages. By following the instructions outlined below, users can accurately identify anonymous *Phlebotomus* specimens by methodologically evaluating the morphological characteristics of the specimens.

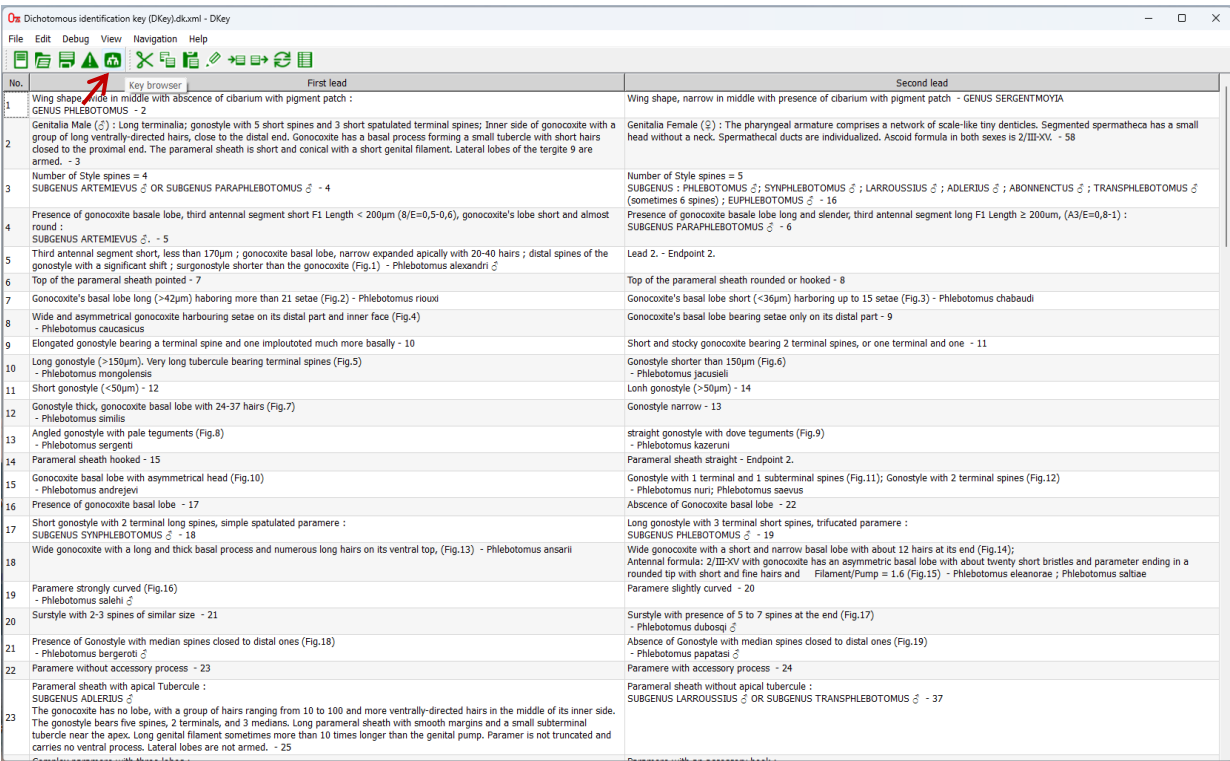
1. Download and install the executive software file of Dkey via <https://github.com/DrawWing/DKey>.
2. Open the Dkey software by clicking on the already installed software



3. Open the dichotomous identification key zip file (containing the key executable file (.dk), along with photos and drawings), which has already been downloaded from the supplementary files of this article and extracted, by clicking on the “File” tab.



4. In the main menu, click on the “Key Browser” tab in the menu bar



5. Select the appropriate tab for the genus of the sand fly specimen, considering the morphological criteria mentioned in each tab

Key browser - DKey

NavigationHelp

1

Wing shape, wide in middle with absence of cibarium with pigment patch :
GENUS *PHLEBOTOMUS*

Wing shape, narrow in middle with presence of cibarium with pigment patch
GENUS *SERGEIMOYA*

Path

Remaining endpoints

Excluded endpoints

6. Select the appropriate tab for the sex of the sand fly specimen, based on the morphological criteria mentioned in each tab.

Key browser - DKey

NavigationHelp

2(1)

Genitalia Male (♂) : Long terminalia; gonostyle with 5 short spines and 3 short spatulated terminal spines; Inner side of gonocoxite with a group of long ventrally-directed hairs, close to the distal end. Gonocoxite has a basal process forming a small tubercle with short hairs closed to the proximal end. The parameral sheath is short and conical with a short genital filament. Lateral lobes of the tergite 9 are armed.

Genitalia Female (♀) : The pharyngeal armature comprises a network of scale-like tiny denticles. Segmented spermatheca has a small head without a neck. Spermathecal ducts are individualized. Ascoid formula in both sexes is 2/III-XV.

Path

Remaining endpoints

Excluded endpoints

7. For example, for males, select the subgenus of the sand fly specimen considering the number of style spines.

3(2)

Number of Style spines = 4
SUBGENUS *ARTEMIEVUS* ♂ OR SUBGENUS *PARAPHLEBOTOMUS* ♂
4

Number of Style spines = 5
SUBGENUS : *PHLEBOTOMUS* ♂; *SYNPHLEBOTOMUS* ♂; *LARROUSSIUS* ♂; *ADLERIUS* ♂; *ABONNENCTUS* ♂; *TRANSPHLEBOTOMUS* ♂ (sometimes 6 spines); *EUPHLEBOTOMUS* ♂
16

Path

2. Genitalia Male (♂) : Long terminalia; gonostyle with 5 short spines and 3 short spatulated terminal spines; Inner side of gonocoxite with a group of long ventrally-directed hairs, close to the distal end. Gonocoxite has a basal process forming a small tubercle with short hairs closed to the proximal end. The parameral sheath is short and conical with a short genital filament. Lateral lobes of the tergite 9 are armed. - 3
1. Wing shape, wide in middle with absence of cbarium with pigment patch :
GENUS *PHLEBOTOMUS* - 2

Remaining endpoints

Phlebotomus andrejevi - 15
Phlebotomus ansarii - 18
Phlebotomus canaaniticus - 41
Phlebotomus caucasicus - 8
Phlebotomus chabaudi - 7
Phlebotomus economidesi - 40
Phlebotomus fortunatarum - 57
Phlebotomus jacusieli - 10
Phlebotomus kazeruni - 13
Phlebotomus major ♂, Phlebotomus neglectus ♂, Phlebotomus syriacus ♂ - 49
Phlebotomus mascitti - 41
Phlebotomus mesghali - 56
Phlebotomus mongolensis - 10
Phlebotomus nadimi - 56
Phlebotomus nuri; Phlebotomus saevus - 15
Phlebotomus riousi - 7
Phlebotomus sergenti - 13
Phlebotomus similis - 12
Phlebotomus Kilicki ♂ - 39

Excluded endpoints

- 64
Phlebotomus alexandri ♀ - 75
Phlebotomus ansarii ♀ - 81
Phlebotomus eleanorae ♀, Phlebotomus saltiae ♀ - 81
Phlebotomus mesghali ♀ - 82
Phlebotomus nadimi ♀ - 82
Phlebotomus simici, Phlebotomus turanicus, Phlebotomus brevis, Phlebotomus halepensis, Phlebotomus kabulensis, Phlebotomus longiductus, Phlebotomus arabicus, Phlebotomus naqbenius, Phlebotomus comatus, Phlebotomus balcanicus, Phlebotomus kyreniae, Phlebotomus salangensis, Phlebotomus creticus - 64
GENUS SERGENTIMOYA - 1
Phlebotomus anatolicus ♀, Phlebotomus kilicki ♀, Phlebotomus simonahalepae ♀, Phlebotomus economidesi ♀ - 62
Phlebotomus ariasi ♀, Phlebotomus perniciosus ♀, Phlebotomus chadlii ♀, Phlebotomus perillievi ♀, Phlebotomus galileus ♀, Phlebotomus transcasicus ♀, Phlebotomus longeroni ♀, Phlebotomus keshishiani ♀, Phlebotomus longicuspis ♀, Phlebotomus kandelaki ♀, Phlebotomus orientalis ♀, Phlebotomus tobbi ♀ - 66
Phlebotomus bergeroti ♀ - 71
Phlebotomus dubosqi ♀ - 72
Phlebotomus fortunatarum ♀ - 60
Phlebotomus ilami ♀ - 67
Phlebotomus jacusieli ♀ - 78

8. For example, by selecting the left tab in the previous section, the subgenera will appear individually with morphological criteria specific to each one.

4(3)

Presence of gonocoxite basale lobe, third antennal segment short F1 Length < 200µm (8/E=0,5-0,6), gonocoxite's lobe short and almost round :
SUBGENUS *ARTEMIEVUS* ♂.
3

Presence of gonocoxite basale lobe long and slender, third antennal segment long F1 Length ≥ 200µm, (A3/E=0,8-1) :
SUBGENUS *PARAPHLEBOTOMUS* ♂
8

Path

3. Number of Style spines = 4
SUBGENUS *ARTEMIEVUS* ♂ OR SUBGENUS *PARAPHLEBOTOMUS* ♂ - 4
2. Genitalia Male (♂) : Long terminalia; gonostyle with 5 short spines and 3 short spatulated terminal spines; Inner side of gonocoxite with a group of long ventrally-directed hairs, close to the distal end. Gonocoxite has a basal process forming a small tubercle with short hairs closed to the proximal end. The parameral sheath is short and conical with a short genital filament. Lateral lobes of the tergite 9 are armed. - 3
1. Wing shape, wide in middle with absence of cbarium with pigment patch :
GENUS *PHLEBOTOMUS* - 2

Remaining endpoints

Phlebotomus andrejevi - 15
Phlebotomus caucasicus - 8
Phlebotomus chabaudi - 7
Phlebotomus jacusieli - 10
Phlebotomus kazeruni - 13
Phlebotomus mongolensis - 10
Phlebotomus nuri; Phlebotomus saevus - 15
Phlebotomus riousi - 7
Phlebotomus sergenti - 13
Phlebotomus similis - 12
Phlebotomus alexandri ♂ - 5
Endpoint 2. - 14
Endpoint 2. - 5

Excluded endpoints

- 64
Phlebotomus alexandri ♀ - 75
Phlebotomus ansarii ♀ - 81
Phlebotomus eleanorae - 18
Phlebotomus canaaniticus - 41
Phlebotomus economidesi - 40
Phlebotomus eleanorae ♀, Phlebotomus saltiae ♀ - 81
Phlebotomus fortunatarum - 57
Phlebotomus major ♂, Phlebotomus neglectus ♂, Phlebotomus syriacus ♂ - 49
Phlebotomus mascitti - 41
Phlebotomus mesghali - 56
Phlebotomus mesghali ♀ - 82
Phlebotomus nadimi - 56
Phlebotomus nadimi ♀ - 82
Phlebotomus simici, Phlebotomus turanicus, Phlebotomus brevis, Phlebotomus halepensis, Phlebotomus kabulensis, Phlebotomus longiductus, Phlebotomus arabicus, Phlebotomus naqbenius, Phlebotomus comatus, Phlebotomus balcanicus, Phlebotomus kyreniae, Phlebotomus salangensis, Phlebotomus creticus - 64
GENUS SERGENTIMOYA - 1
Phlebotomus Kilicki ♂ - 39

9. For example, by selecting the left tab in the previous section, the *Phlebotomus* species belonging to this subgenus will appear. By following the morphological criteria given in mentioned couplet, the *Phlebotomus* specimen will be identified at the species/subspecies level (for example, in this case, *Phlebotomus alexandri*). Each species is described morphologically, accompanied by micrographs and drawings.

5(4)
Third antennal segment short, less than 170µm; gonocoxite basal lobe, narrow expanded apically with 20-40 hairs; distal spines of the gonostyle with a significant shift; sargonostyle shorter than the gonocoxite (Fig 1)
Phlebotomus alexandri ♂

Path
4. Presence of gonocoxite basal lobe, third antennal segment short F1 Length < 200µm (9/E=0,5-0,6), gonocoxite's lobe short and almost round :
SUBGENUS ARTEMIEVUS ♂ - 5
3. Number of Style spines = 4
SUBGENUS ARTEMIEVUS ♂ OR SUBGENUS PARAPHEBOTOMUS ♂ - 4
2. Genitalia Male (♂) : Long terminalia; gonostyle with 5 short spines and 3 short spatulated terminal spines; inner side of gonocoxite with a group of long ventrally-directed hairs, close to the distal end. Gonocoxite has a basal process forming a small tubercle with short hairs closed to the proximal end. The parameral sheath is short and conical with a short genital filament. Lateral lobes of the tergite 9 are armed. - 3
1. Wing shape, wide in middle with absence of cibarium with pigment patch :
GENUS PHLEBOTOMUS - 2

Remaining endpoints
Phlebotomus alexandri ♂ - 5
Endpoint 2, - 5

Excluded endpoints
- 64
Phlebotomus alexandri ♀ - 75
Phlebotomus andrejevi - 15
Phlebotomus ansarii ♀ - 81
Phlebotomus ansarii - 18
Phlebotomus canaaniticus - 41
Phlebotomus caucasicus - 8
Phlebotomus chabaudi - 7
Phlebotomus economidesi - 40
Phlebotomus eleonorae ♀, Phlebotomus saltiae ♀ - 81
Phlebotomus fortunaturnum - 57
Phlebotomus jacuseli - 10
Phlebotomus kazeruni - 13
Phlebotomus major ♂, Phlebotomus neglectus ♂, Phlebotomus syriacus ♂ - 49
Phlebotomus mascitti - 41
Phlebotomus mesghali - 56
Phlebotomus mesghali ♀ - 82
Phlebotomus mongolensis - 10
Phlebotomus nadimi - 56

10. You can navigate through the different couplets by typing the couplet number in the “Navigation” tool of “Key Browser”. For example, if you want to directly view couplet N°39 on the left side, simply enter the number 39 in the “Go to couplet number” field of “Navigation” section of the “Key Browser”.

1
Wing shape, wide in middle with absence of cibarium with pigment patch :
GENUS PHLEBOTOMUS
2
Wing shape, narrow in middle with presence of cibarium with pigment patch
GENUS SERGENTMOTIA

Path

Remaining endpoints
- 64
Phlebotomus alexandri ♀ - 75
Phlebotomus andrejevi - 15
Phlebotomus ansarii ♀ - 81
Phlebotomus ansarii - 18
Phlebotomus canaaniticus - 41
Phlebotomus caucasicus - 8
Phlebotomus chabaudi - 7
Phlebotomus economidesi - 40
Phlebotomus eleonorae ♀, Phlebotomus saltiae ♀ - 81
Phlebotomus fortunaturnum - 57
Phlebotomus jacuseli - 10
Phlebotomus kazeruni - 13
Phlebotomus major ♂, Phlebotomus neglectus ♂, Phlebotomus syriacus ♂ - 49
Phlebotomus mascitti - 41
Phlebotomus mesghali - 56
Phlebotomus mesghali ♀ - 82
Phlebotomus mongolensis - 10
Phlebotomus nadimi - 56

Go to couplet...
Go to couplet number:
39
OK Cancel

References

1. Tofilski A (2018) DKey software for editing and browsing dichotomous keys. ZooKeys 735: 131-140. <https://doi.org/10.3897/zookeys.735.21412>