An updated checklist of the Culicidae (Diptera) of Morocco, with notes on species of historical and current medical importance

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ABSTRACT: An updated checklist of the mosquito species (Diptera: Culicidae) recorded in Morocco from 1916 to 2016 is provided, including synonyms and synonymous usage for each species. Forty-three species belonging to seven genera are recorded so far: *Anopheles* (9), *Aedes* (12) *Coquillettidia* (2), *Culex* (12), *Culiseta* (5), *Orthopodomyia* (1) and *Uranotaenia* (2). Traditional and equivalent names in the polyphyletic concept of *Aedes* are provided for the aedine species. The historical importance and current potential threat of mosquitoes to human health in Morocco is reviewed. ***Journal of Vector Ecology* 42 (1): 94-104. 2017.**

Keyword Index: Checklist, Diptera, Culicidae, Morocco, North Africa, mosquitoes.

INTRODUCTION

The first and preliminary list of the mosquitoes of Morocco was included in the bibliographic review of Trari et al. (2002), who reviewed all studies of Moroccan mosquitoes published from 1916 to 2001. Since that publication, the invasive species *Aedes albopictus* (aka *Stegomyia albopicta*) has been found in Morocco (Bennouna et al. 2016), thus 43 species are now known to occur in the country. In addition, major taxonomic changes have been made to the classification of the tribe Aedini (Reinert et al. 2004, 2006, 2008, 2009, Wilkerson et al. 2015), with the formal recognition of many new generic-level taxa. Many of the genera which Reinert et al. (2009) recognized in their classification of Aedini were reduced to subgenera in a very large composite genus *Aedes* by Wilkerson et al. (2015). Thus, whereas the 43 species of Culicidae known to occur in Morocco comprise 11 genera in the classification of Reinert et al. (2009), including *Anopheles* (9 species), *Acartomyia* (1), *Aedimorphus* (1), *Coquillettidia* (2), *Culex* (12), *Culiseta* (5), *Dahliana* (2), *Ochlerotatus* (6), *Orthopodomyia* (1), *Stegomyia* (2), and *Uranotaenia* (2), they comprise seven genera in the revised traditional classification of Wilkerson et al. (2015) where *Acartomyia*, *Aedimorphus*, *Dahliana*, *Ochlerotatus,* and *Stegomyia* are treated as subgenera of *Aedes*.

An inventory of currently recognized Moroccan taxa, with synonyms and previous usage, is provided herein. This listing is organized alphabetically as in the world catalogue of Knight and Stone (1977). The aedine species, following Wilkerson et al. (2015), are listed as species of *Aedes* along with the equivalent generic combinations of Reinert et al. (2009). The latter are included because the generic designations of Reinert et al. (2009) are accepted and used by some researchers (e.g., Batovska et al. 2016, Natarajan et al. 2016), and it is important to include them to avoid confusion and foster comparison with previous literature.

The subgenera *Anopheles* and *Cellia* of the genus *Anopheles* are divided into hierarchical systems of informal taxonomic categories (Reid and Knight 1961, Harbach 1994, 2004, 2013, 2016), but due to the small number of species (nine) of this genus in Morocco, the informal categories of classification are not included in the checklist. The two-letter and three-letter abbreviations for genera and subgenera, respectively, provided by Reinert et al. (2009) and Wilkerson et al. (2015) are used herein. Synonyms and/or synonymous usage are drawn from Trari et al. (2004) and Gaffigan et al. (2015).

The present paper has two purposes. Firstly, it is intended to update the inventory of species and clarify confusing usage of names in the Moroccan literature, to aid the preparation of a catalog and to provide a better understanding of the distributions of the mosquitoes of Morocco (Trari and Kakki 2017). Secondly, it aims to review the historical association of mosquitoes and disease as a backdrop to the current threat of mosquito-borne pathogens to human health in Morocco. Up-to-date information on the mosquitoes of Morocco is of considerable importance in view of climate change and the increasing number of exotic species and pathogens that are being transported around the world and introduced into new areas with susceptible populations. Indeed, climate change is responsible for modifications in the migration patterns of birds that are reservoirs and disseminators of arboviruses. Given the geographic location of Morocco in relation to migratory pathways, which encompasses one of the main routes of Palaearctic-Afrotropical migration, arboviral outbreaks may occur in the country. In fact, this is confirmed by the three recent outbreaks of West Nile virus (including one fatal case in 1996) that occurred in the northwest of Morocco (El Harrak et al. 1997, Schuffenecker et al. 2005, Fassil et al. 2011). For these reasons, some information on the biology and medical importance of the Moroccan mosquito fauna is provided at the end of the checklist that follows.

CHECKLIST

Subfamily Anophelinae Grassi, 1900
Genus *Anopheles* Meigen, 1818
Subgenus *Anopheles* Meigen, 1818

1. *An.* (*Ano.*) *algeriensis* Theobald, 1903
- Synonym:
  - *An. lukisii* Christophers, 1916
- Previous (synonymous) usage:
  - *An. aitkenii* auctorum
  - *An. algeriensis* var. *turkestani* Shingarev
  - *An. bifurcatus* auctorum (in part)
  - *An. bifurcatus* var. *algeriensis* auctorum
  - *An. fragilis* of Searle *nec* Theobald
  - *An. martinius* Shingarev

2. *An.* (*Ano.*) *claviger* (Meigen, 1804)
- Synonyms:
  - *An. algeriensis* var. *turkestani* Shingarev, 1926
  - *An. amaurus* Martini, 1929
  - *An. claviger* var. *pollutus* Torres Cañamares, 1945
  - *An. grisescens* Stephens, 1828
  - *An. habibi* Mulligan & Puri, 1936
  - *An. missiroli* del Vecchio, 1939
  - *An. villosus* Robineau-Desvoidy, 1827
- Previous (synonymous) usage:
  - *An. antennatus* of Senevet 1935; Senevet 1958; Guy 1959b
  - *An. bifurcatus* of Senevet1935; Senevet 1958; Guy 1959b
  - *An. claviger* of Guy 1959a
  - *An. claviger petragnani* form *saheliensis* of Guy 1959a
  - *An. portucaliensis* de Figueiredo of Senevet 1958

3. *An.* (*Ano.*) *marteri* Senevet & Prunnelle, 1927
- Synonyms: none
- Previous (synonymous) usage: none

4. *An.* (*Ano.*) *labranchiae* Falleroni, 1926
- Synonyms:
  - *An. maculipennis pergusae* Missiroli, 1935
  - *An. maculipennis* var. *sicaulti* Roubaud, 1935
- Previous (synonymous) usage: none

5. *An.* (*Ano.*) *ziemanni* Gruenberg, 1902
- Synonyms: none
- Previous (synonymous) usage:
  - *An. coustani* Laveran
  - *An. mauritianus coustani* auctorum
  - *An. mauritianus* de Grandpre & de Charmoy
  - *An. paludis* var. *similis* Theobald

Subgenus *Cellia* Theobald, 1902

6. *An.* (*Cel.*) *dthali* Patton, 1905
- Synonym:
  - *An. wardi* Leeson & Theodor, 1948
- Previous (synonymous) usage:
  - *An. rhodesiensis* Theobald

7. *An.* (*Cel.*) *sergentii* (Theobald, 1907)
- Synonyms: none
- Previous (synonymous) usage:
  - *An. culicifacies* Giles
  - *Pyretophorus sergentii* Theobald

8. *Anopheles* (*Cel.*) *cinereus* Theobald, 1901
- Synonym:
  - *An. jehafi* Patton, 1905
- Previous (synonymous) usage:
  - *An. cinereus hispaniola* (Theobald)
  - *An. italicus* Raffaele
  - *An. pictus* of Senevet (1958)
  - *An. rifenus* Baeza Cuellar
  - *An. turkhudi* of Guy (1959c)
  - *Pyretophorus myzomyifacies* Theobald

9. *Anopheles* (*Cel.*) *multicolor* Cambouliu, 1902
- Synonyms:
  - *An. impunctus* Dönitz, 1902
  - *Pyretophorus chaudoyei* Theobald, 1903
  - *Pyretophorus nigrifasciatus* Theobald, 1907
- Previous (synonymous) usage:
  - *An. nigrifasciatus* Theobald
  - *An. cleopatrae* Willcocks, 1910 (currently regarded as a *nomen nudum*)

Subfamily Culicinae Meigen, 1818
Tribe Aedini Neveu-Lemaire, 1902
Genus *Aedes* Meigen, 1818
Subgenus *Acartomyia* Theobald, 1903

10. *Ae.* (*Acy.*) *mariae* (Sergent & Sergent, 1903)
- [*Acartomyia mariae* (Sergent & Sergent, 1903)]
- Synonym:
  - *Aedes desbansi* Séguy, 1923
- Previous (synonymous) usage:
  - *Aedes dzeta* Séguy
  - *Aedes epsilon* Séguy
  - *Aedes mariae* of Sergent & Sergent (1903)
  - *Aedes zammitii* Theobald

Subgenus *Aedimorphus* Theobald, 1903

11. *Ae.* (*Adm.*) *vexans* (Meigen, 1830)
- [*Aedimorphus vexans* (Meigen, 1830)]
- Synonyms:
  - *Aedes eurochrus* Howard, Dyar & Knab, 1917
  - *Culex articulatus* Rondani, 1872
  - *Culex malariae* Grassi, 1898
  - *Culex minuta* Theobald, 1907
  - *Culex montcalmi* Blanchard, 1905
  - *Culex parvus* Macquart, 1834
  - *Culex sudanensis* Theobald, 1911
  - *Culex sylvestris* Theobald, 1901
  - *Culicada eruthrosops* Theobald, 1910
- Previous (synonymous) usage:
  - *Culex vagans* Theobald (listed by Séguy1924 as a synonym)
  - *Aedes vexans* Meigen
  - *Culex arabiensis* Patton
  - *Culex nocturnus* Theobald
  - *Culex nocturnus* var. *niger* Theobald
  - *Culicada nipponii* Theobald

Subgenus *Dahliana* Reinert, Harbach & Kitching, 2006

12. *Ae.* (*Dah.*) *echinus* (Edwards, 1920)

[*Dahliana echinus* (Edwards, 1920)]

Synonyms: none

Previous (synonymous) usage:

Aedes echinus (Edwards)
Culex geniculatus Olivier
Finlaya echina (Edwards)
Ochlerotatus echinus Edwards

13. *Ae.* (*Dah.*) *geniculatus* (Olivier, 1791)

[*Dahliana geniculata* (Olivier, 1791)

Synonyms:

Culex albo-punctatus Rondani, 1872
Culex guttatus Curtis, 1835
Culex guttatus Meigen, 1818
Culex lateralis Meigen, 1818
Culex ornatus Meigen, 1818

Previous (synonymous) usage:

Aedes geniculatus (Olivier)
Culex fusculus Zetterstedt
Culex geniculatus Olivier
Finlaya geniculata (Olivier)

Subgenus *Ochlerotatus* Lynch Arribálzaga, 1891

14. *Ae.* (*Och.*) *berlandi* Séguy, 1921

[*Ochlerotatus berlandi* (Séguy, 1921)]

Synonyms:

Aedes heracleensis (Callot, 1944)
Aedes longitubus Cambournac, 1938
Aedes praeteritus Séguy, 1923

Previous (synonymous) usage:

Aedes berlandi Séguy

15. *Ae.* (*Och.*) *caspius* (Pallas, 1771)

[*Ochlerotatus caspius* Pallas, 1771)]

Synonyms:

Aedes epsilonn Séguy, 1924
Aedes quaylei Dyar & Knab, 1906
Culex arabicus Becker, 1910
Culex curriei Coquillett, 1901
Culex lativittatus Coquillett, 1906
Culex maculiventris Macquart, 1846
Culex onondagensis Felt, 1904
Culex penicillaris Rondani, 1872
Culex punctatus Meigen, 1804
Culex siculus Robineau-Desvoidy, 1827
Grabhamia broquetii Theobald, 1913
Grabhamia longisquamosa Theobald, 1905
Grabhamia subtilis Sergent & Sergent, 1905
Grabhamia willcocksii Theobald, 1907
Mansonia arabica Giles, 1906
Taeniorhynchus africanus Neveu-Lemaire, 1906

Previous (synonymous) usage:

Aedes caspius (Pallas)
Culex caspius Pallas

16. *Ae.* (*Och.*) *coluzzii* Rioux, Guilvard & Pasteur, 1998

[*Ochlerotatus coluzzii* (Rioux, Guilvard & Pasteur, 1998)]

Synonym:

Aedes detritus sibling species A (reported as a synonym by Rioux et al. 1998)

Previous (synonymous) usage:

Aedes coluzzii Rioux, Guilvard & Pasteur

17. *Ae.* (*Och.*) *detritus* (Haliday, 1833)

[*Ochlerotatus detritus* (Haliday, 1833)]

Synonyms:

Culex salinus Ficalbi, 1896
Culex terriei Theobald, 1903
Grabhamia maculosa Theobald, 1905
Culex salinus Ficalbi, 1896
Culex nemorosus salinus Theobald, 1901
Culex terriei Theobald, 1903

Previous (synonymous) usage:

Aedes detritus (Haliday)
Aedes detritus sibling species B (see Rioux et al. 1998)
Culex nemorosus salinus Theobald of Séguy, 1924

18. *Ae.* (*Och.*) *pulcritarsis* (Rondani, 1872)

[*Ochlerotatus pulcritarsis* (Rondani, 1872)]

Synonyms:

Culex leucacanthus Loew, 1873
Aedes pulcritarsis var. *stegomyina* Stackelberg & Monchadskii, 1926
Aedes simici Baranoff, 1927

Previous (synonymous) usage:

Culex pulcritarsis Rondani
Aedes pulcritarsis (Rondani)

Subgenus *Rusticoidus* Shevchenko & Prudkina, 1973

19. *Ae.* (*Rus.*) *rusticus* (Rossi, 1790)

[*Ochlerotatus* (*Rus.*) *rusticus* (Rossi, 1790)]

Synonyms:

Culex diversus Theobald, 1901
Culex maculatus Meigen, 1804
Culex musicus Leach, 1825
Culex nemorosus var. *luteovittata* Theobald, 1901
Culex quadratimaculatus Macquart, 1834
Culex pungens Robineau-Desvoidy, 1827

Previous (synonymous) usage:

Aedes rusticus (Rossi)
Culex rusticus Rossi

Subgenus *Stegomyia* Theobald, 1901

20. *Ae.* (*Stg.*) *aegypti* (Linnaeus, 1762)

[*Stegomyia* (*Stg.*) *aegypti* (Linnaeus, 1762)]

Synonyms:

Culex albopalposus Becker, 1908
Culex anguste-alatus Becker, 1908
Culex annulitarsis Macquart, 1846
Culex argenteus Poiret, 1787
Culex bancrofti Skuse, 1889
Culex calopus Meigen, 1818
Culex elegans Ficalbi, 1890
Culex exagitans Walker, 1856
Culex excitans Walker, 1848
Culex fasciatus Fabricius, 1805
Culex frater Robineau-Desvoidy, 1827
Culex inexorabilis Walker, 1848

Culex insatiabilis Bigot, 1859
Culex kounoupi Brullé, 1833
Culex mosquito Robineau-Desvoidy, 1827
Culex rossii Giles, 1899
Culex sugens Wiedemann, 1828
Culex taeniatus Wiedemann, 1828
Culex toxorhynchus Macquart, 1838
Culex viridifrons Walker, 1848
Duttonia alboannulis Ludlow, 1911
Mimeteomyia pulcherrima Taylor, 1919
Stegomyia calopus var. *canariensis* Pittaluga, 1905
Stegomyia fasciata var. *atritarsis* Edwards, 1920
Stegomyia fasciata var. *luciensis* Theobald, 1901
Stegomyia fasciata var. *persistans* Banks, 1906
Stegomyia fasciata var. *queenslandensis* Theobald, 1901
Stegomyia lamberti Ventrillon, 1904
Stegomyia nigeria Theobald, 1901

Previous (synonymous) usage:
Aedes aegypti (Linnaeus)
Culex fasciatus Fabricius

21. *Ae.* (*Stg.*) *albopictus* (Skuse, 1895)
[*Stegomyia* (subgenus uncertain) *albopicta* (Skuse, 1895)]
Synonyms:
Stegomyia scutellaris samarensis Ludlow, 1903
Stegomyia nigritia Ludlow, 1910
Stegomyia quasinigritia Ludlow, 1911
Previous (synonymous) usage:
Culex albopictus Skuse

Tribe Culicini Meigen, 1818
Genus *Culex* Linnaeus, 1758
Subgenus *Barraudius* Edwards, 1921

22. *Cx.* (*Bar.*) *modestus* Ficalbi, 1889
Synonyms:
Culex eadithae Barraud, 1924
Culex nudipalpis, Shingarev, 1927
Culex tanajcus Stschelkanovzev, 1926
Previous (synonymous) usage:
Culex fusculus Zetterstedt

Subgenus *Culex* Linnaeus, 1758

23. *Cx.* (*Cux.*) *brumpti* Galliard, 1931
Synonyms: none
Previous (synonymous) usage: none

24. *Cx.* (*Cux.*) *laticinctus* Edwards, 1913
Synonyms: none
Previous (synonymous) usage: none

25. *Cx.* (*Cux.*) *simpsoni* Theobald, 1905
Synonyms:
Culex mauritanicus Callot, 1940
Culex richteri Ingram & de Meillon, 1927
Previous (synonymous) usage: none

26. *Cx.* (*Cux.*) *mimeticus* Noè, 1899
Synonym:
Culex pseudomimeticus Sergent, 1909
Previous (synonymous) usage: none

27. *Cx.* (*Cux.*) *perexiguus* Theobald, 1903
Synonyms: none
Previous (synonymous) usage:
Culex univittatus Theobald

28. *Cx.* (*Cux.*) *pipiens* Linnaeus, 1758
Synonyms:
Culex agilis Bigot, 1889
Culex autogenicus sternopallidus Roubaud, 1945
Culex autogenicus sternopunctatus Roubaud, 1945
Culex azoriensis Theobald, 1903
Culex bicolor Meigen, 1818
Culex pallipes Macquart, 1838
Culex agilis Bigot, 1889
Culex azoriensis Theobald, 1903
Culex bicolor Meigen, 1818
Culex bifurcatus Linnaeus, 1758
Culex calcitrans Robineau-Desvoidy, 1827
Culex comitatus Dyar and Knab, 1909
Culex consobrinus Robineau-Desvoidy, 1827
Culex domesticus Germar, 1817
Culex fasciatus Müller, 1754
Culex haematophagus Ficalbi, 1893
Culex longefurcatus Becker, 1903
Culex luteus Meigen, 1804
Culex marginalis Stephens, 1825
Culex melanorhinus Giles, 1900
Culex meridionalis Leach, 1825
Culex molestus Forskål, 1775
Culex osakaensis Theobald, 1907
Culex pallipes Macquart, 1838
Culex pallipes Waltl, 1835
Culex phytophagus Ficalbi, 1890
Culex pipiens autogenicus Roubaud, 1935
Culex pipiens berbericus Roubaud, 1935
Culex pipiens calloti Rioux & Pech 1959
Culex pipiens erectus Iglisch, 1977
Culex pipiens disjunctus Roubaud, 1957
Culex pipiens torridus Iglisch, 1977
Culex pipiens var. *doliorum* Edwards, 1912
Culex quasimodestus Theobald, 1905
Culex rufinus Bigot, 1888
Culex rufus Meigen, 1818
Culex thoracicus Robineau-Desvoidy, 1827
Culex trifurcatus Fabricius, 1794
Culex unistriatus Curtis, 1837
Culex varioannulatus Theobald, 1903
Previous (synonymous) usage: none

29. *Cx.* (*Cux.*) *theileri* Theobald, 1903
Synonyms:
Culex alpha Séguy, 1924
Culex creticus Theobald, 1903
Culex onderstepoortensis Theobald, 1911
Culex pettigrewii Theobald, 1910
Culex theileri var. *annulata* Theobald, 1913
Previous (synonymous) usage: none

Subgenus *Maillotia* Theobald, 1907

30. *Cx.* (*Mai.*) *deserticola* Kirkpatrick, 1925
Synonyms: none
Previous (synonymous) usage: none
31. *Cx.* (*Mai.*) *hortensis* Ficalbi, 1889
Synonyms:
Culex lavieri Larrousse, 1925
Maillotia pilifera Theobald, 1907
Previous (synonymous) usage: none

Subgenus *Neoculex* Dyar, 1905
32. *Cx.* (*Ncx.*) *impudicus* Ficalbi, 1890
Synonym:
Culex sergentii Theobald, 1903
Previous (synonymous) usage: none
33. *Cx .* (*Ncx.*) *martinii* Medschid, 1930
Synonyms: none
Previous (synonymous) usage: none

Tribe Culisetini Belkin, 1962
Genus *Culiseta* Felt, 1904
Subgenus *Allotheobaldia* Brolemann, 1919
34. *Cs.* (*All.*) *longiareolata* (Macquart, 1838)
Synonyms:
Culex annulatus var. *marocanus* D'Anfreville, 1916
Culex leucogrammus Loew, 1874
Culex serratipes Becker, 1908
Culex spathipalpis Rondani, 1872
Previous (synonymous) usage:
Culex longiareolata Macquart
Theobaldia longiareolata (Macquart)

Subgenus *Culicella* Felt, 1904
35. *Cs.* (*Cuc.*) *fumipennis* (Stephens, 1825)
Synonyms:
Culex ficalbii Noè, 1899
Culicada theobaldi de Meijere, 1911
Theobaldia setivalva Monchadskii, 1936
Previous (synonymous) usage: none
36. *Cs.* (*Cuc.*) *litorea* (Shute, 1928)
Previous (synonymous) usage:
Culicella morsitans var. *litorea* Shute
Theobaldia litorea Marshall & Staley

Subgenus *Culiseta* Felt, 1904
37. *Cs.* (*Cus.*) *annulata* (Schrank, 1776)
Synonyms:
Culex affinis Stephens, 1825
Culex annulatus Fabricius, 1787
Culex annulatus Fourcroy, 1785
Culex nicaensis Leach, 1825
Theobaldia annulata var. *ferruginata* Martini, 1924
Previous (synonymous) usage:
Theobaldia annulata (Schrank)
38. *Cs.* (*Cus.*) *subochrea* (Edwards, 1921)
Synonyms: none
Previous (synonymous) usage:
Theobaldia subochrea Edwards

Tribe Mansoniini Belkin, 1962
Genus *Coquillettidia* Dyar, 1905
Subgenus *Coquillettidia* Dyar, 1905
39. *Cq.* (*Coq.*) *buxtoni* (Edwards, 1923)
Synonyms: none
Previous (synonymous) usage:
Taeniorhynchus buxtoni Edwards
40. *Cq.* (*Coq.*) *richiardii* (Ficalbi, 1889)
Synonyms:
Taeniorhynchus nikolskyi Shingarev, 1927
Previous (synonymous) usage:
Culex richiardii Ficalbi
Mansonia richiardii (Ficalbi)

Tribe Orthopodomyiini Belkin, Heinemann & Page, 1970
Genus *Orthopodomyia* Theobald, 1904
41. *Or. pulcripalpis* (Rondani, 1872)
Synonym:
Orthopodomyia albionensis MacGregor, 1919
Previous (synonymous) usage:
Culex pulcripalpis Rondani

Tribe Uranotaeniini Lahille, 1904
Genus *Uranotaenia* Lynch Arribálzaga, 1891
Subgenus *Pseudoficalbia* Theobald, 1912
42. *Ur.* (*Pfc.*) *unguiculata* Edwards, 1913
Synonyms: none
Previous (synonymous) usage: none
Subgenus *Uranotaenia* Lynch Arribálzaga, 1891
43. *Ur.* (*Ura.*) *balfouri* Theobald, 1904
Synonyms: none
Previous (synonymous) usage: none

REVIEW OF MOROCCAN MOSQUITOES OF MEDICAL IMPORTANCE

Trari (Ph.D. thesis, Université Mohammed V, Rabat) reviewed the mosquitoes of Morocco and their historical and present relation to human disease. An objective of her thesis was to summarize, as completely as possible, the literature that contains information about the Moroccan species which previously had and could now play a role in the transmission of pathogenic agents. The available information pertaining to 23 species of known and potential medical importance is consolidated here.

1. *Aedes aegypti*

Aedes aegypti is the main vector of yellow fever (Soper 1967, Tabachnick 1991) and dengue fever viruses (Rodhain 1996, Le Goff et al. 2011, Brady et al. 2014,). It is also capable of transmitting other arboviruses, such as Chikungunya (Dupont-Rouzeyrol et al. 2012, Paupy et al. 2010, Vega-Rúa et al. 2014), West Nile (Hubálek and Halouzka 1999), and Zika viruses (Marchette et al. 1969, Diagne et al. 2015, Chouin-Carneiro et al. 2016).

2. *Aedes albopictus*

Aedes albopictus, native to southeastern Asia, is one of the most invasive species in the world (Medlock et al. 2015). It has been expanding in geographical range over the past two decades, colonizing the Americas, Europe, and Africa (Paupy et al. 2009). The species is an efficient vector of dengue fever and chikungunya viruses (Haddad et al. 2012, Paupy et al. 2010) but is also capable of transmitting a number of other arboviruses (Gratz 2004a,b), such as yellow fever (Tabachnick 1991), Japanese encephalitis (Weng et al. 1999), West Nile (Haddad et al. 2012, Turell et al. 2001), Sindbis (Bowers et al. 2003), and Zika viruses (Chouin-Carneiro et al. 2016).

3. *Aedes caspius*

Aedes caspius is a vector of West Nile, Tahyna, and Sindbis viruses in Europe (Moussiegt 1988, Lundström 1999). Tahyna virus was isolated from *Ae. caspius* in Germany (Pilaski and Mackenstein 1985) and West Nile virus in Bulgaria (Hubálek and Halouzka 1999) and Ukraine (Hubálek 2000, Hubálek and Halouzka 1999). This species can also transmit microfilariae (*Dirofilaria immitis*) (Ferreira et al. 2015) and appears to be (with *Ae. vexans*) the most important vector of filarial parasites (*Dirofilaria immitis* and *D. repens*) in Italy (Gratz 2004a). The species has also been found infected with avian *Plasmodium* in southern Spain (Ferraguti et al. 2013) and may transmit myxomatosis virus (Joubert et al. 1967).

4. *Aedes detritus*

Aedes detritus is not known as a major vector of parasitic agents of human diseases (Ribeiro et al. 1988), however this species is particularly sensitive to Chikungunya virus (Vazeille et al. 2008). It may also transmit myxomatosis virus (Joubert et al. 1967) and the agent of canine dirofilariasis (*Dirofilaria immitis*) (Ferreira et al. 2015).

5. *Aedes mariae*

Aedes mariae is not known to be of medical importance to humans, but it is capable of transmitting parasites to birds (Gutsevich et al. 1974).

6. *Aedes vexans*

Aedes vexans is capable to transmitting viruses that include equine and St. Louis encephalitis viruses (Turell et al. 2001), West Nile virus (Turell et al. 2001, Gratz 2004a, Molaei and Andreadis 2006, Tiawsirisup et al. 2008), Tahyna virus (Pilaski and Mackenstein 1985), and Rift Valley fever virus (Fontenille et al. 1995, 1998). This species is also a vector of microfilariae (Reinert 1973, Gratz 2004a).

7. *Anopheles algeriensis*

Anopheles algeriensis has been considered an incidental vector of malarial protozoa in northern Africa (Horsfall 1972), and was identified as the species responsible for malaria transmission in Algeria during the early part of the twentieth century (Sergent and Sergent 1905). It has been considered a secondary vector in Morocco, but its role in transmission was negligible due to its scarcity (Gaud 1953, Guy 1959d).

8. *Anopheles cinereus*

Anopheles cinereus is generally considered to be of no medical importance. However, sporozoites were found in this species during an epidemic of malaria in southern Morocco (Midelt) in the early 1960s. It was the only species found in the region at the time (Guy 1963).

9. *Anopheles claviger*

Anopheles claviger was considered an effective principal vector of malarial protozoa in the High Atlas Mountains of Morocco (Vermeil and Doby 1950), but this was questioned by Guy and Holstein (1968).

10. *Anopheles dthali*

Anopheles dthali is suspected of playing a role in the transmission of malarial protozoa south of the Atlas Mountains, but its vector status has never been proven (Trari et al. 2004, Trari and Carnevale 2011).

11. *Anopheles labranchiae*

Anopheles labranchiae, a member of the Holarctic *An. maculipennis* group, is the most efficient vector of malaria protozoa in the Palearctic Region (Mouchet et al. 2004, Sinka et al. 2010). In Morocco, it is unquestionably the main vector (Trari et al. 2004, Trari and Carnevale 2011), having been responsible for the transmission of *Plasmodium vivax*, *P. malariae* and *P. falciparum* in the country in the past (Gaud et al. 1949).

12. *Anopheles marteri*

The role of *An. marteri* as a vector of malarial protozoa seems doubtful (Ribeiro et al. 1988), and any involvement would probably have been limited in Morocco (Trari et al. 2004, Trari and Carnevale 2011).

13. *Anopheles multicolor*

Anopheles multicolor was considered the most important vector of malarial protozoa in the Saharan regions of Algeria (Foley 1923). This species played a significant role in malaria transmission in the south of Morocco in the mid-1900s (Guy 1959d). It is also capable to transmitting Rift Valley Fever virus, which was discovered during epidemics of the disease in Egypt (Gad et al. 1987).

14. *Anopheles sergentii*

According to Guy (1963), *An. sergentii* played a role in the transmission of malarial protozoa in the south of Morocco while *An. labranchiae* was involved in the north of the country. However, its role was difficult to prove because its distribution overlaps that of *An. labranchiae* in the central area of the country.

15. *Anopheles ziemanni*

Anopheles ziemanni does not seem to play a significant role in the transmission of malarial protozoa in Morocco (Senevet and Andarelli 1956, Guy 1959d).

16. *Coquillettidia richiardii*

Coquillettidia richiardii, along with *Cx. pipiens* and *Cx. modestus*, is known to transmit West Nile virus in Europe (Hubálek

and Halouzka 1999).

17. *Culex impudicus*

Culex impudicus is thought to be capable of transmitting West Nile virus in Italy (Romi et al. 2004).

18. *Culex mimeticus*

Culex mimeticus is a suspected vector of West Nile virus in Portugal (Almeida et al. 2010).

19. *Culex modestus*

Culex modestus is considered to be highly susceptible to infection of West Nile virus (Hannoun et al. 1964, Mouchet et al. 1970, Hubálek 2000, Bodker et al. 2014, Vaux et al. 2015, Cotar et al. 2016). This species has also been found to carry Japanese encephalitis virus in China (Anonymous 1980) and avian *Plasmodium* species in southern Spain (Ferraguti et al. 2013). It may also be involved in the transmission of myxomatosis virus (Joubert et al. 1967) and Tahyna virus (Danielová and Holubova 1976).

20. *Culex perexiguus*

Culex perexiguus is a vector of West Nile virus (Cornel et al. 1993, Miller et al. 2000, Jupp 2001). It is an important vector of this virus in Africa, the Middle East (Hubálek and Halouzka 1999) and Europe (Muñoz et al. 2012, Balenghien et al. 2008). The virus was isolated recently from *Cx. perexiguus* in southern Spain (Vázquez et al. 2011), which was also found to harbor avian *Plasmodium* species (Ferraguti et al. 2013).

21. *Culex pipiens*

Culex pipiens is a vector of arboviruses known to occur in Europe, for example West Nile virus (Gratz 2004a, Lundström 1999), and it was involved in the recent West Nile virus outbreak in the U.S.A. (Andreadis 2012, Fechter-Leggett et al. 2012, Richards et al., 2014). This species contributes to virus circulation in several countries, including South Africa, Egypt, Israel, Bulgaria (Hubálek and Halouzka 1999), Romania, Czech Republic (Hubálek and Halouzka 1999, Hubálek 2000), Sweden (Francy et al. 1989.), Italy (Romi et al. 2004, Calzolari et al. 2010), France (Balenghien et al. 2008), Portugal (Esteves et al. 2005, Almeida et al. 2008), Spain (Muñoz et al. 2012), Tunisia (Krida et al. 2015.), Algeria (Benallal et al. 2015), and Morocco (Amraoui et al. 2012).*Culex pipiens* is also capable of transmitting other viruses in Europe, such as Tahyna (Lundström 1999) and Sindbis viruses (Francy et al. 1989, Lundström 1999). In the Mediterranean region, *Cx. pipiens* would also be capable of transmitting Rift Valley fever virus (Moutailler et al. 2008, Krida et al. 2011) and is suspected to be primarily responsible for outbreaks of this virus during epidemics that occurred among humans in Egypt (Gad et al. 1999). Additionally, *Cx. pipiens* may be a natural vector of avian malarial protozoa (Lalubin et al. 2013), Japanese encephalitis virus (Ravanini et al. 2012), and microfilariae (Harb et al. 1993, Abdel-Hamid et al. 2011, Ferreira et al. 2015).

22. *Culex theileri*

Culex theileri is capable of transmitting arboviruses that include West Nile, Tahyna, and Sindbis viruses (Lundström 1999). This species has been found to be naturally infected with *Dirofilaria immitis* (dog heartworm) in Iran (Azari-Hamidian et al. 2009) and Portugal (Ferreira et al. 2015). This species was found carrying avian *Plasmodium* in the south of Spain (Ferraguti et al. 2013) and could also play a role in the transmission of *Dirofilaria immitis* (Martínez-de la Puente et al. 2012).

23. *Culiseta annulata*

Culiseta annulata is capable of transmitting Tahyna virus (Danielová et al. 1970, Danielová 1972, Bárdos et al. 1975).

CONCLUSIONS

The mosquito fauna of Morocco includes 43 species, 23 of which are recognized vectors or potential vectors of mosquito-borne pathogens. Because of the confusing use of names for mosquitoes in the Moroccan literature, all synonymous usage is included in the list to better understand the distributions of the species and provide insights into their ecological associations as an aid for bionomical studies.

REFERENCES CITED

Abdel-Hamid, Y.M., M.I. Soliman, and M.A. Kenawy. 2011. Mosquitoes (Diptera: Culicidae) in relation to the risk of disease transmission in El Ismailia Governorate, Egypt. J. Egypt. Soc. Parasitol. 41: 347–356.

Almeida, A.P.G., F.B. Freitas, M.T. Novo, C.A. Sousa, J.C. Rodrigues, R. Alves, and A. Esteves. 2010. Mosquito surveys and West Nile virus screening in two different areas of southern Portugal, 2004–2007. Vector-Borne Zoonot. Dis. 10: 673–680.

Almeida, A.P.G., R.P. Galão, C.A. Sousa, M.T. Novo, R. Parreira, J. Pinto, J. Piedade, and A. Esteves. 2008. Potential mosquito vectors of arboviruses in Portugal: species, distribution, abundance and West Nile infection. Trans. R. Soc. Trop. Med. Hyg. 102: 823–832.

Amraoui, F., G. Krida, A. Bouattour, A. Rhim, J. Daaboub, Z. Harrat, S.-C. Boubidi, M. Tijane, M. Sarih, and A.-B. Failloux. 2012. *Culex pipiens,* an experimental efficient vector of West Nile and Rift Valley fever viruses in the Maghreb Region. PLoS One 7: e36757.

Andreadis, T.G. 2012. The contribution of *Culex pipiens* complex mosquitoes to transmission and persistence of West Nile virus in North America. J. Am. Mosq. Contr. Assoc. 28 (4 suppl.): 137–151.

Anonymous. 1980. Isolation of Japanese B encephalitis virus from *Culex* (*Barraudius*) *modestus* Ficalbi in Shenyang area [in Chinese]. Zhonghua Yu Fang Yi Xue Za Zhi [Chin. J. Prev. Med.] 14: 209–210.

Azari-Hamidian, S., M.R. Yaghoobi-Ershadi, E. Javadian, M.R. Abai, I. Mobedi, Y.-M. Linton, and R.E. Harbach. 2009. Distribution and ecology of mosquitoes in a focus of dirofilariasis in northwestern Iran, with the first finding of filarial larvae in naturally infected local mosquitoes. Med. Vet. Entomol. 23: 111–121.

Balenghien, T., M. Vzeille, M. Grandadam, F. Schaffner, H. Zeller, P. Reiter, P. Sabatier, F. Fouque, and D.J. Bicout. 2008. Vector

competence of some French *Culex* and *Aedes* mosquitoes for West Nile virus. Vector-Borne Zoonot. Dis. 8: 589–595.

Bárdos, V., J. Tyba, and Z. Hubálek. 1975. Isolation of Tahyna virus from field collected *Culiseta annulata* (Schrk.) larvae. Acta Virol. 19: 446.

Batovska, J., M.J. Blacket, K. Brown, and S.E. Lynch. 2016. Molecular identification of mosquitoes (Diptera: Culicidae) in southeastern Australia. Ecol. Evol. 6: 3001–3011.

Benallal, K., S. Benbetka, G. Tail, and Z. Harrat. 2015. Molecular characterization of *Culex pipiens* (Diptera, Culicidae) in Reghaïa lake, Algeria. Ann. Biol. Sci. 3: 20–24.

Bennouna, A., T. Balenghien, H. El Rhaffouli, F. Schaffner, C. Garros, L. Gardès, Y. Lhor, S. Hammouni, G. Chlyeh, and O.F. Fihri. 2016. First record of *Aedes albopictus* (Diptera: Culicidae) in Morocco: a major threat to public health in northern Africa? Med. Vet. Entomol. (Early view article) doi: 10.1111/mve.12194.

Bowers, D.F., C.G. Coleman, and D.T. Brown. 2003. Sindbis virus-associated pathology in *Aedes albopictus* (Diptera: Culicidae). J. Med. Entomol. 40: 698–705.

Brady, O.J., N. Golding, D.M Pigott, M.U.G. Kraemer, J.P. Messina, R.C. Reiner Jr., T.W. Scott, D.L. Smith, P.W. Gething, and S.I. Hay. 2014. Global temperature constraints on *Aedes aegypti* and *Ae. albopictus* persistence and competence for dengue virus transmission. Parasit. Vectors 7: 338.

Calzolari, M., P. Bonilauri, R. Bellini, A. Albieri, F. Deilippo, G. Maioli, G. Galletti, A. Gelati, I. Barieri, M. Ramba, D. Lelli, E. Carra, P. Cordioli, P. Angelini, and M. Dottori. 2010. Evidence of simultaneous circulation of West Nile and Usutu viruses in mosquitoes sampled in Emilia-Romagna Region (Italy) in 2009. PLoS One 5: e1432.

Chouin-Carneiro, T., A. Vega-Rua, M. Vazeille, A. Yebakima, R. Girod, D. Goindin, M. Dupont-Rouzeyrol, R. Lourenço-de-Oliveira, and A.-B. Failloux. 2016. Differential susceptibilities of *Aedes aegypti* and *Aedes albopictus* from the Americas to Zika Virus. PLoS Negl. Trop. Dis. 10: e0004543.

Cornel, A.J., P.G. Jupp, and N.K. Blackburn. 1993. Environmental temperature on the vector competence of *Culex univittatus* (Diptera: Culicidae) for West Nile virus. J. Med. Entomol. 30: 449–456.

Cotar, A., E. Falcuta, L.F. Prioteasa, S. Dinu, C.S. Ceianu, and S. Paz. 2016. Transmission dynamics of the West Nile Virus in mosquito vector populations under the influence of weather factors in the Danube Delta, Romania. EcoHealth (Epub ahead of print) doi:10.1007/s10393-016-1176-y.

Danielová, V. (1972). The vector efficiency of *Culiseta annulata* mosquito in relation to Tahyna virus. Folia Parasitol. 19: 259–262.

Danielová, V. and J. Holubova. 1976. Two more mosquito species proved as vectors of *Ťahyňa* virus in Czechoslovakia. Folia Parasitol. 24: 187–189.

Danielová, V., J. Minář, and J. Ryba. 1970. Isolation of *Ťahyňa* virus from mosquitoes *Culiseta annulata* (Schrk. [*sic*] 1776). Folia Parasitol. 17: 281–284.

Diagne, C.T., D. Diallo, O. Faye, Y. Ba, O. Faye, A. Gaye, I. Dia, O. Faye, S.C. Weaver, A.A. Sall, and M. Diallo. 2015. Potential of selected Senegalese *Aedes* spp. mosquitoes (Diptera: Culicidae) to transmit Zika virus. BMC Infect. Dis. 15: 492.

Dupont-Rouzeyrol, M., V. Caro, L. Guillaumot, M. Vazielle, E. D'Ortenzio, J.-M. Thiberge, N. Baroux, A.-C. Gourinat, M. Grandadam, and A.-B. Failloux. 2012. Chikungunya virus and the mosquito vector *Aedes aegypti* in New Caledonia (South Pacific Region).Vector-Borne Zoo. Dis. 12: 1036–1041.

El Harrak, M., B. Le Guenno, and P. Gounon. 1997. Isolement du virus West Nile au Maroc. Virologie 1: 248–249.

Esteves, A., A.P.G. Almeida, R.P. Galão, R. Parreira, J. Piedade, J.C. Rodriguez, C.A. Sousa, and M.T. Novo. 2005. West Nile virus in southern Portugal, 2004. Vector-Borne Zoonot. Dis. 5: 410–413.

Fassil, H., M. El Harrak, and J.-L. Marié. 2011. Aspects épidémiologiques de l'infection à virus West-Nile au Maroc. Méd. Santé Trop. 22: 123–125.

Fechter-Leggett, E., B.M. Nelms, C.M. Barker, and W.K. Reisen. 2012. West Nile virus cluster analysis and vertical transmission in *Culex pipiens* complex mosquitoes in Sacramento and Yolo Counties, California, 2011. J. Vector Ecol. 37: 442–449.

Ferraguti, M., J. Martinez-de la Puente, J. Muñoz, D. Roiz, S. Ruiz, R. Soriguer, and J. Figuerola. 2013. Avian *Plasmodium* in *Culex* and *Ochlerotatus* mosquitoes from southern Spain: Effects of season and host-feeding source on parasite dynamics. PLoS One 8: e66237.

Ferreira, C.A.C., V. de Pinho Mixão, M.T.L.M. Novo, M.M.P. Calado, L.A.P. Gonçalves, S.M.D. Belo, and A.P.G. de Almeida. 2015. First molecular identification of mosquito vectors of *Dirofilaria immitis* in continental Portugal. Parasit. Vectors 8: 139.

Foley, H. 1923. Les moustiques du Sahara algérien. Arch. Inst. Pasteur Alger. 1: 295–300.

Fontenille, D., M. Traore-Lamizana, M. Diallo, J. Thonnon, J.P. Digoutte, and H.G. Zeller. 1998. New vectors of Rift Valley fever in West Africa. Emerg. Infect. Dis. 4: 289–293.

Fontenille, D., M. Traore-Lamizana, H. Zeller, M. Mondo, M. Diallo, and J.-P. Digoutte. 1995. Short report: Rift Valley fever in western Africa: isolations from *Aedes* mosquitoes during an interepizootic period. Am. J. Trop. Med. Hyg. 52: 403–404.

Francy, D.B., T.G.T. Jaenson, J.L. Lundström, E.B., Schildt, *Å*. Espmark, B. Nenriksson, and V. Niklasson. 1989. Ecologic studies of mosquitoes and birds as hosts of Ockelbo virus in Sweden and isolation of Inkoo and Batai viruses from mosquitoes. Am. J. Trop. Med. Hyg. 41: 355–363.

Gad, A.M., H.A. Farid, R.R.M. Ramzy, M.B. Riad, S.M. Presley, S.E. Cope, M.M. Hassan, and A.N. Hassan. 1999. Host feeding of mosquitoes (Diptera: Culicidae) associated with the recurrence of Rift Valley fever in Egypt. J. Med. Entomol. 36: 709–714.

Gad, A.M., M.M. Hassan, S. el Said, M.I. Moussa, and O.L. Wood. 1987. Rift Valley fever virus transmission by different Egyptian mosquito species. Trans. R. Soc. Trop. Med. Hyg. 81: 694–698.

Gaffigan, T.V., R.C. Wilkerson, J.E. Pecor, J.A. Stoffer, and T. Anderson. 2015. Systematic Catalog of Culicidae, http://www.mosquitocatalog.org (accessed 2 July 2016).

Gaud, J. 1953. Larves d'Anophèles à palettes thoraciques hyperchitinisées. Ann. Parasitol. Hum. Comp. 28: 326–328.

Gaud, J., D. Mechali, and J. Delrieu. 1949. Riziculture et paludisme au Maroc. Bull. Inst. Hyg. Maroc 9: 181–190.

Gratz, N.G. 2004a. The mosquito-borne infections of Europe. Eur. Mosq. Bull. [J. Eur. Mosq. Contr. Assoc.] 17: 1–7.

Gratz, N.G. 2004b. Critical review of the vector status of *Aedes albopictus*. Med. Vet. Entomol. 18: 215–227.

Gutsevich, A.V., A.S. Monchadskii, and A.A. Shtakel'berg. 1974. *Fauna of the U.S.S.R. Diptera. Volume 3, No. 4. Mosquitoes Family* Culicidae [*sic*]. Keter Publishing House Jerusalem Ltd, Jerusalem.

Guy, Y. 1959a. Les sous-espèces marocaines d'*Anopheles claviger* Meigen, 1804. Bull. Soc. Sci. Nat. Phys. Maroc 39: 9–12.

Guy, Y. 1959b. Les Anophèles du Maroc. Mem. Soc. Sci. Nat. Phys. Maroc Zool. 7: 235.

Guy, Y. 1959c. Mise en synonymie d'*Anopheles turkhudi mysomyifacies* Gaud avec *Anopheles hispaniola* Theobald. Bull. Soc. Sci. Nat. Phys. Maroc 39: 13–18.

Guy, Y. 1959d. Les rapports entre l'anophélisme et le paludisme. Bull. Soc. Sci. Nat. Phys. Maroc 39: 83–90.

Guy, Y. 1963. Bilan épidémiologique du paludisme au Maroc (données recueillies entre 1960, 1961 et 1962). Ann. Parasit. Hum. Comp. 38: 823–857.

Guy, Y. and M. Holstein. 1968. Données récentes sur les anophèles du Maghreb. Arch. Inst. Pasteur Alger. 46: 142–150.

Haddad, N., L. Mousson, M. Vazeille, S. Chamat, J. Tayeh, M.A. Osta, and A.-B. Failloux.2012. *Aedes albopictus* in Lebanon, a potential risk of arboviruses outbreak. BMC Infect. Dis. 12: 300.

Hannoun, C., R. Panthier, J. Mouchet, and J.P. Eouzan. 1964. Isolement en France du virus West Nile à partir de malades et du vecteur *Culex modestus* Ficalbi. C.R. Hebd. Seances Acad. Sci. 259: 4170–4172.

Harb, M., R. Faris, A.M. Gad, O.N. Hafez, R. Ramzy, and A.A. Buck. 1993. The resurgence of lymphatic filariasis in the Nile Delta. Bull. Wld. Hlth. Organ. 71: 49–54.

Harbach, R.E. 1994. Review of the internal classification of the genus *Anopheles* (Diptera: Culicidae): the foundation for comparative systematics and phylogenetic research. Bull. Entomol. Res. 84: 331–342.

Harbach, R.E. 2004. The classification of genus *Anopheles* (Diptera: Culicidae): a working hypothesis of phylogenetic relationships. Bull. Entomol. Res. 94: 537–553.

Harbach, R.E. 2013. The phylogeny and classification of *Anopheles*, 3–55. In: S. Manguin, (ed.), *Anopheles Mosquitoes - New Insights into Malaria Vectors*. InTech, Rijeka, Croatia.

Harbach, R.E. 2016. *Anopheles* classification. Mosquito Taxonomic Inventory, http://mosquito-taxonomic-inventory.info/node/11358 (accessed 15 September 2016).

Horsfall, W.R. 1972. *Mosquitoes, their bionomics and relation to disease*. Hafner Publishing Company, New York.

Hubálek, Z. 2000. European experience with the West Nile virus ecology and epidemiology: Could it be relevant for the New World? Viral Immunol. 13: 415–426.

Hubálek, Z. and J. Halouzka. 1999. West Nile Fever—a reemerging mosquito-borne viral disease in Europe. Emerg. Infect. Dis. 5: 643–650.

Joubert, L., J. Oudar, J. Mouchet, and Cl. Hannoun. 1967. Transmission de la myxomatose par les moustiques en Camargue: Rôle prééminent d'*Aedes caspius* et des *Anophèles* du groupe *maculipennis*. Bull. Acad. Vet. Fr. 40: 315–322.

Jupp, P.G. 2001. The ecology of West Nile virus in South Africa and the occurrence of outbreaks in humans. Ann. N. Y. Acad. Sci. 951: 143–152.

Knight, K.L. and A. Stone. 1977. A catalog of the mosquitoes of the world (Diptera: Culicidae). Second edition. Thomas Say Found. 6: 1–611.

Krida, G., L. Diancourt, A. Bouattour, A. Rhim, B. Chermiti, and A.-B. Failloux. 2011. Estimation du risque d'introduction du virus de la fièvre de la vallée du Rift en Tunisie par le moustique *Culex pipiens.* Bull. Soc. Pathol. Exot. 104: 250–259.

Krida, G., A. Rhim, J. Daaboub, A.-B. Failloux, and A. Bouattour. 2015. New evidence for the potential role of *Culex pipiens* mosquitoes in the transmission cycle of West Nile virus in Tunisia. Med. Vet. Entomol. 29: 124–128.

Lalubin, F., A. Delédevant, O. Glaizot, and P. Christe. 2013. Temporal changes in mosquito abundance (*Culex pipiens*), avian malaria prevalence and lineage composition. Parasit. Vectors 6: 307.

Le Goff, G., J. Revollo, M. Guerra, M. Cruz, Z.B. Simon, Y. Roca, J.V. Florès, and J.-P. Hervé. 2011. Natural vertical transmission of dengue viruses by *Aedes aegypti* in Bolivia. Parasite 18: 277–280.

Lundström, J.O. 1999. Mosquito-borne viruses in western Europe: a review. J. Vector Ecol. 24: 1–39.

Marchette, N.J., R. Garcia, and A. Rudnick. 1969. Isolation of Zika virus from *Aedes aegypti* mosquitoes in Malaysia. Am. J. Trop. Med. Hyg. 18: 411–415.

Martínez-de la Puente, J., I. Moreno-Indias, L.E. Hernández-Castellano, A. Argüello, S. Ruiz, R. Soriguer, and J. Figuerola. 2012. Host-feeding pattern of *Culex theileri* (Diptera: Culicidae), potential vector of *Dirofilaria immitis* in the Canary Islands, Spain. J. Med. Entomol. 49: 1419–1423.

Medlock, J.M., K.M. Hansford, V. Versteirt, B. Cull, H. Kampen, D. Fontenille, G. Hendrickx, H. Zeller, W. Van Bortel, and F. Schaffner. 2015. An entomological review of invasive mosquitoes in Europe. Bull. Entomol. Res. 105: 637–663.

Miller, B.R., R.S. Nasci, M.S. Godsey, H.M. Savage, J.J. Lutwama, R.S. Lanciotti, and S.J. Peters. 2000. First field evidence for natural vertical transmission of West Nile virus in *Culex univittatus* complex mosquitoes from Rift Valley Province, Kenya. Am. J. Trop. Med. Hyg. 62: 240–246.

Molaei, G. and T.G. Andreadis. 2006. Identification of avian- and mammalian-derived bloodmeals in *Aedes vexans* and *Culiseta melanura* (Diptera: Culicidae) and its implication for West Nile virus transmission in Connecticut, U.S.A. J. Med. Entomol. 43: 1088–1093.

Mouchet, J., P. Carnevale, M. Coosemans, J. Julvez, S. Manguin, D. Richard-Lenoble, and J. Sircoulon. 2004. *Biodiversité du paludisme dans le monde*. John Libbey Eurotext, Paris.

Mouchet, J, J. Rageau, C. Laumond, C. Hannoun, D. Beytout, J. Oudar J, B. Corniou, and A. Chippaux. 1970. Epidémiologie du virus West Nile: étude d'un foyer en Camargue. V-Le vecteur: *Culex modestus* Ficalbi Diptera; Culicidae. Ann. Inst. Pasteur 118: 839–855.

Moussiegt, O. 1988. *Aedes* (*Ochlerotatus*) *caspius* (Pallas, 1721). Bibliographie. Document E.I.D. No. 45. Montpellier.

Moutailler, S., G. Krida, F. Schaffner, M. Vazeille, and A.-B. Failloux. 2008. Potential vectors of Rift Valley fever virus in

the Mediterranean Region. Vector-Borne Zoonot. Dis. 8: 749–754.

Muñoz, J., S. Ruiz, R. Soriguer, M. Alcaide, D.S. Viana, D. Roiz, A. Vázquez, and J. Figuerola. 2012. Feeding patterns of potential West Nile virus vectors in south-west Spain. PLoS One 7: e39549.

Natarajan, R., A.R. Rajavel, and P. Jambulingam. 2016. Description of a new species of the genus *Hulecoeteomyia* (Diptera: Culicidae) from Meghalaya, India. Zootaxa 4137: 330–338.

Paupy, C., H. Delatte, L. Bagny, V. Corbel, and D. Fontenille. 2009. *Aedes albopictus*, an arbovirus vector: From the darkness to the light. Microbes Infect. 11: 1177–1185.

Paupy, C., B. Ollomo, B. Kamgang, S. Moutailler, D. Rousset, M. Demanou, J.-P. Nervé, E. Leroy, and F. Simard. 2010. Comparative role of *Aedes albopictus* and *Aedes aegypti* in the emergence of dengue and chikungunya in central Africa. Vector-Borne Zoonot. Dis. 10: 259–266.

Pilaski, J. and H. Mackenstein. 1985. Isolation of Tahyna virus from mosquitoes in two different European natural foci [in German]. Zentralbl. Bakteriol. Mikrobiol. Hyg. 1. Abt. Orig. B, Hyg. 180: 394–420.

Ravanini, P., E. Huhtamo, V. Ilaria, M.G. Crobu, A.M. Nicosia, L. Servino, F. Rivasi, S. Allegrini, U. Miglio, A. Magri, R. Minisini, O. Vapalahti, and R. Boldorini. 2012. Japanese encephalitis virus RNA detected in *Culex pipiens* mosquitoes in Italy. Euro Surveill. 17(28): pii=20221.

Reid, J.A. and K.L. Knight. 1961. Classification within the subgenus *Anopheles* (Diptera, Culicidae). Ann. Trop. Med. Parasitol. 55: 474–488.

Reinert, J.F. 1973. Contributions to the mosquito fauna of Southeast Asia. – XVI. Genus *Aedes* Meigen, subgenus *Aedimorphus* Theobald in Southeast Asia. Contrib. Am. Entomol. Inst. 9: 1–218.

Reinert, J.F. 2009. List of abbreviations for currently valid generic-level taxa in family Culicidae (Diptera). Eur. Mosq. Bull. [J. Eur. Mosq. Contr. Assoc.] 27: 68–76.

Reinert, J.F., R.E. Harbach, and I.J. Kitching. 2004. Phylogeny and classification of *Aedini* (Diptera: Culicidae) based on morphological characters of all life stages. Zool. J. Linn. Soc. 142: 289–368.

Reinert, J.F., R.E. Harbach, and I.J. Kitching. 2006. Phylogeny and classification of *Finlaya* and allied taxa (Diptera: Culicidae: Aedini) based on morphological data from of all life stages. Zool. J. Linn. Soc. 148: 1–101.

Reinert, J.F., R.E. Harbach, and I.J. Kitching. 2008. Phylogeny and classification of *Ochlerotatus* and allied taxa (Diptera: Culicidae: Aedini) based on morphological data from all life stages. Zool. J. Linn. Soc. 153: 29–114.

Reinert, J.F., R.E. Harbach, and I.J. Kitching. 2009. Phylogeny and classification of Aedini (Diptera: Culicidae). Zool. J. Linn. Soc. 157: 700–794 + 2 online appendices.

Ribeiro, H., H. da Cunha Ramos, C.A. Pires, and R. Antenues Capela. 1988. An annotated checklist of the mosquitoes of continental Portugal *(Diptera Culicidae)* [*sic*]. Actas III Congr. Ibérico Entomol. Grenada 233–253.

Richards, S.L., S.L. Anderson, and C.C. Lord. 2014. Vector competence of *Culex pipiens quinquefasciatus* (Diptera: Culicidae) for West Nile virus isolates from Florida. Trop. Med. Int. Hlth. 19: 610–617.

Rioux, J.A., E. Guilvard, and N. Pasteur. 1998. Description d'*Aedes* (*Ochlerotatus*) *coluzzii* n. sp. (Diptera, Culicidae), espèce jumelle A du complexe *detritus*. Parassitologia 40: 353–360.

Rodhain, F. 1996. La situation de la dengue dans le monde. Bull. Soc. Pathol. Exot. 89: 87–90.

Romi, R., G. Pontuale, M.G. Ciufolini, G. Fiorentini, A. Marchi, L. Nicoletti, M. Cocchi, and A. Tamburro. 2004. Potential vectors of West Nile Virus following an equine disease outbreak in Italy. Med. Vet. Entomol. 18: 14–19.

Schuffenecker, I., C.N. Peyrefitte, M. el Harrak, S. Murri, A. Leblond, and H.G. Zeller. 2005. West Nile virus in Morocco, 2003. Emerg. Infect. Dis. 11: 306–309.

Séguy, E. 1924. *Les Moustiques de l'Afrique mineure, de l'Égypte et de la Syrie.* Encyclopédie Entomologique, Paul Lechevalier, Paris.

Senevet, G. 1935. *Les Anophèles de la France et de ses colonies.* Encyclopédie Entomologique, Paul Lechevalier, Paris.

Senevet, G. 1958. *Les Anophèles du Globe. Révision générale.* Encyclopédie Entomologique, XXXVI, Paul Lechevalier, Paris.

Senevet, G. and L. Andarelli. 1956. *Les Anophèles de l'Afrique du Nord et du Bassin Méditerranéen.* Encyclopédie entomologique: Série A. 33 Travaux généraux. Paul Lechevalier, Paris.

Sergent, Ed. and Ét. Sergent. 1903. Observations sur les moustiques des environs d'Alger. Ann. Inst. Pasteur 17: 60–67.

Sergent, Ed. and Ét. Sergent. 1905. Les Insectes piqueurs inoculateurs de maladies infectieuses dans l'Afrique du Nord. In: *Comptes Rendus du Congrès de Sociétés Savantes (Sciences)*, Imprimerie Nationale, Paris.

Sinka, M.E., M.J. Bangs, S. Manguin, M. Coetzee, C.M. Mbogo, J. Hemingway, A.P. Patil, W.H. Temperley, P.W. Gething, C.W. Kabaria, R.M. Okara, T. van Boeckel, H.C.J. Godfray, R.E. Harbach, and S.I. Hay. 2010. The dominant *Anopheles* vectors of human malaria in Africa, Europe and the Middle East: occurrence data, distribution maps and bionomic précis. Parasit. Vectors 3: 117.

Soper, F.L. 1967. *Aedes aegypti* and yellow fever. Bull. Wld. Hlth. Org. 36: 521–527.

Tabachnick, W.J. 1991. Evolutionary genetics and arthropod-borne disease: The yellow fever mosquito. Am. Entomol. 37: 14–26.

Tiawsirisup, S., J.R. Kinley, B.J. Tucker, R.B. Evans, W.A. Rowley, and K.B. Platt. 2008. Vector competence of *Aedes vexans* (Diptera: Culicidae) for West Nile virus and potential as an enzootic vector. J. Med. Entomol. 45: 452–457.

Trari, B. and P. Carnevale. 2011. De la préélimination à l'élimination du paludisme au Maroc. Quels risques pour l'avenir? Bull. Soc. Pathol. Exot. 104: 291–295.

Trari, B. and M. Dakki. 2017. Atlas des moustiques (Diptera Culicidae) du Maroc: distribution, bioécologie et role vecteur. Trav. Inst. Sci., Sér. Zool. (in press).

Trari, B., M. Dakki, O. Himmi, and M.A. El Agbani. 2002. Les moustiques (Diptera Culicidae) du Maroc. Revue bibliographique (1916–2001) et inventaire des espèces. Bull. Soc. Pathol. Exot. 95: 329–334.

Trari, B., R.E. Harbach, O. Himmi, M. Dakki, and A. Agoumi. 2004. An inventory of the mosquitoes of Morocco. I. Genus

Anopheles (Diptera: Culicidae). Eur. Mosq. Bull. [J. Eur. Mosq. Control Assoc.], 18: 1–19.

Turell, M.J., M.L. O'Guinn, D.J. Dohm, and J.W. Jones. 2001. Vector competence of North American mosquitoes (Diptera: Culicidae) for West Nile virus. J. Med. Entomol. 38: 130–134.

Vazeille, M., C. Jeannin, E. Martin, F. Schaffner, and A.-B. Failloux. 2008. Chikungunya: A risk for Mediterranean countries? Acta Trop. 105: 200–202.

Vázquez, A., S. Ruiz, L. Herrero, J. Moreno, F. Molero, A. Magallanes, M.P. Sánchez-Seco, J. Figuerola, and A. Tenorio. 2011. West Nile and Usutu viruses in mosquitoes in Spain, 2008–2009. Am. J. Trop. Med. Hyg. 85: 178–181.

Vega-Rúa, A., K. Zouache, R. Girod, A.-B. Failloux, and R. Lourenço-de-Oliveira. 2014. High vector competence of *Aedes aegypti* and *Aedes albopictus* from ten American countries as a crucial factor of the spread of Chikungunya. J. Virol. 88: 6294–6306.

Vermeil, C. and J.M. Doby. 1950. Présence *d'Anopheles d'thali* [*sic*] Patton dans le sud tunisien. Bull. Soc. Pathol. Exot. 43: 443–444.

Weng, M.H., J.C. Lien, Y.M. Wang, C.C. Lin, H.C. Lin, and C. Chin. 1999. Isolation of Japanese encephalitis virus from mosquitoes collected in Northern Taiwan between 1995 and 1996. J. Microbiol. Immunol. Infect. 32: 9–13.

Wilkerson, R.C., Y.-M. Linton, D.M. Fonseca, T.R. Schultz, D.C. Price, and D.A. Strickman. 2015. Making mosquito taxonomy useful: A stable classification of tribe Aedini that balances utility with current knowledge of evolutionary relationships. Plos One 10: e0133602.