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Keys to the adult female mosquitoes (Culicidae) of Greece

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Abstract.

Revised keys are provided for the identification of the adult female mosquitoes of Greece. Fifty-seven species representing eight genera are recognised. Separate keys are included for the genera and the species and subspecies belonging to each genus. The keys include a number of new characters that have not been used previously for the identification of European mosquitoes.

Introduction

Despite the long history of taxonomic study in Europe, the taxonomy of European mosquitoes is far from complete. There are many questions regarding the formal status of various nominal species and subspecies, and the entire mosquito fauna is generally poorly known. No modern, comprehensive treatment exists for any group in any part of the region and most of the published keys and species descriptions are scattered through the literature. There are a number of works on the mosquitoes of certain countries and certain parts of the region, but these are generally out of date or limited in scope and treatment.

As in most countries of Europe, the mosquito fauna of Greece is not thoroughly known. A number of works on the mosquitoes of certain parts of the country were completed during the first three decades of the present century. These mainly involved anopheline mosquitoes because malaria was a serious public health problem at that time. Later works include only species lists and, most recently, keys for the identification of the mosquitoes of Greece (Darsie & Samanidou-Voyadjoglou, 1997). Samanidou-Voyadjoglou & Darsie (1993), Snow & Ramsdale (1999) and Ramsdale & Snow (2000) assembled lists of references dealing both directly and indirectly with the mosquito fauna of Greece. Reasons for the renewed interest in the Culicidae of Greece that has come about in recent years include the threat of malaria reintroduction, the serological diagnosis of mosquito-borne viruses in humans (Antoniadis, 1990) and the unbearable nuisance of mosquitoes in some areas of the country.

During November and December 1998, an extensive examination of mosquito species known to occur in Greece was accomplished at The Natural History Museum, London. The main purpose was to achieve a better understanding of the morphological variation of the species in the adult and larval stages. However, time and a paucity of specimens precluded a meaningful study of larvae. It is not surprising, in view of the generally incomplete knowledge of European mosquitoes, that a number of previously little known or unknown anatomical characters were observed in the adults of certain species. Henceforth, an effort was made to find new characters that might aid and improve the identification of species.

The results of this effort prompted a revision of the keys of Darsie & Samanidou-Voyadjoglou (1997). The revised keys, which include some new anatomical characters, are presented below to aid both specialists and non-specialists in the identification of mosquitoes they are studying or trying to control. Users should be aware, however, that the keys are regarded as preliminary because too few specimens were available to determine the reliability of all the characters, both new and traditional. A thorough knowledge of the Culicidae of Greece will require considerable additional study of individually reared specimens specifically collected during systematic surveys throughout the country.

A number of taxonomic changes have taken place since the publication of Darsie & Samanidou-Voyadjoglou (1997). Most important among these is the reclassification of genus *Aedes*, which resulted in the elevation of subgenus *Ochlerotatus* to generic status (Reinert, 2000). This taxonomic action is followed here; however, because adult mosquitoes of these genera are distinguished primarily on the basis of genitalic characters that require dissection, the species belonging to these genera are included in a single key.

Darsie & Samanidou-Voyadjoglou (1997) included *An. cinereus hispaniola*, *An. melanoon* and *An. petragnani* in their keys to species of *Anopheles*. As Ramsdale & Snow (2000) pointed out, records of *An. cinereus* in Greece (Lividas, 1931; Pandazis, 1935) are erroneous and probably refer to *An. superpictus*. Consequently, *An. cinereus hispaniola* is not considered to be an element of the Greek mosquito fauna and is not included in the key below. Darsie & Samanidou-Voyadjoglou apparently included *An. melanoon* in their keys based on records of *An. melanoon subalpinus* reported by Livadas & Sphangos (1941) and Samanidou-Voyadjoglou & Darsie (1993). However, Cianchi *et al.* (1987) provided evidence of reproductive isolation between sympatric populations of *melanoon* and *subalpinus*, and Ribeiro *et al.* (1988) subsequently formally elevated the latter to full species status. For this reason, *An. subalpinus* is included in the key below in place of *An. melanoon*, which is not known to occur in Greece. Darsie & Samanidou-Voyadjoglou stated that Knight & Stone (1977) reported *An. petragnani* from Greece, but this is incorrect. Knight & Stone merely indicate that this species occurs in the Mediterranean region. According to Ramsdale & Snow (2000), *An. petragnani* appears to be confined to western Mediterranean countries from Italy to Portugal. Since there are no published records of this species in Greece, it is not included in the key presented here.

Ochlerotatus cantans and *Oc. annulipes* are extremely similar in adult habtitus and extreme caution should be used when identifying these two species because they are only reliably distinguished on the basis of male genitalic characters. While this paper was nearing completion, we learned that *Oc. cataphylla*, *Oc. communis*, *Oc. pullatus*, *Oc. punctor* and *Oc. sticticus* were recently discovered in Greece (Achim Kaiser, personal communication). The presence of *Oc. communis* in Greece was previously regarded as uncertain (Snow & Ramsdale, 1999). To be up to date as possible, we have incorporated these five species into the key for *Aedes* and *Ochlerotatus* based on the examination of type specimens and other material in The Natural History Museum.

For the most part, the keys include anatomical characters that are easy to observe. Users must keep in mind, however, that old mosquitoes and light-trapped specimens are often difficult to identify because characters are often defaced or damaged. The anatomical terminology used in the keys is taken from Harbach & Knight (1980).

KEYS TO ADULT FEMALE MOSQUITOES OF GREECE

KEY TO GENERA

1. Maxillary palpi about as long as proboscis; scutellum evenly rounded, with setae evenly spaced (subfamily Anophelinae) ..... *Anopheles*
– Palpi 0.5 or less length of proboscis; scutellum trilobed, with setae in 3 distinct groups (subfamily Culicinae) 2

2(1) Cell R_2 of wing less than 0.5 length of vein R_{2+3}; anal vein ends before intersection of mcu and CuA ..... *Uranotaenia unguiculata*
– Cell R_2 of wing more than 0.5 length of vein R_{2+3}; anal vein ends beyond intersection of mcu and CuA 3

3(2). Prespiracular setae present; base of subcosta on undersurface of wing with patch of setae ..... *Culiseta*
– Prespiracular setae absent; base of subcosta without setae ventrally 4

4(3). Fore- and midtarsomere 1 longer than tarsomeres 2-5 combined, and tarsomere 4 shorter than 5; maxillary palpi 0.5 length of proboscis; scutum with delicate white lines ..... *Orthopodomyia pulcripalpis*
– Fore- and midtarsomere 1 shorter than tarsomeres 2-5 combined, and tarsomere 4 longer than 5; maxillary palpi about 0.3 or less length of proboscis; scutum with another scale pattern 5

5(4). Postspiracular setae present; abdomen generally pointed apically ..... *Aedes* and *Ochlerotatus*
– Postspiracular setae absent; abdomen generally rounded and blunt apically 6

6(5). Pulvilli conspicuous, ungues (claws) small; hindtarsomere 1 as long or longer than hindtibia (except *Cx. modestus*, subgenus *Barraudius*) ..... *Culex*

– Pulvilli inconspicuous, ungues large; hindtarsomere 1 distinctly shorter than hindtibia ..... *Coquillettidia*

SUBFAMILY ANOPHELINAE

KEY TO SPECIES OF *ANOPHELES*

1. Wing with contrasting pale and dark spots 2

– Wing entirely dark-scaled (apical pale fringe sometimes in *maculipennis* complex) (subgenus *Anopheles* in part) 4

2(1). Anterior margin of wing with at least 4 separate dark areas (spots) involving costa, radius and radius-one (subgenus *Cellia*) 3

– Anterior margin of wing with fewer than 4 separate dark areas involving these veins (subgenus *Anopheles* in part) 12

3(2). Scutum with broad pale scales on median area; upper proepisternal setae absent; presector pale spot of wing present ..... *superpictus*

– Scutum with narrow pale scales on median area; upper proepisternal setae present; presector pale spot of wing absent ..... *sergentii*

4(1). Frontal tuft entirely dark; scutum without pale scales on median longitudinal area (uniformly reddish-brown scaled) ..... *algeriensis*

– Frontal tuft pale; scutum with pale scales on longitudinal median area 5

5(4). Wing with clusters (spots) of darker scales at crossveins and furcations (*maculipennis* complex) 6

– Wing scales uniformly distributed, without distinct clusters of darker scales 9

6(5). Integument of scutum light brown; scutal fossa without fine golden scales; clusters of darker scales of wing apparent but not prominent ..... *sacharovi*

– Integument of scutum dark brown; scutal fossa with fine golden scales on at least extreme anterior margin 7

7(6). Wing with slender plume scales on vein R, scales gradually tapering toward tip ..... *atroparvus* and *labranchiae*

– Wing with broad plume scales on vein R 8

8(7). Wing with plume scales on vein R tapering acutely toward tip ..... *subalpinus*

– Wing with plume scales on vein R wider than *subalpinus*, tapering less acutely toward tip ..... *maculipennis* and *messeae*

9(5). Labella distinctly paler than remainder of proboscis; foretarsomere 1 longer than foretarsomeres 2-5 combined 10

– Labella no paler than remainder of proboscis; foretarsomere 1 shorter than or equal to foretarsomeres 2-5 combined 11

10(9). Scutum with broad median longitudinal whitish stripe on anterior half ..... *marteri marteri*

– Scutum greyish yellow with narrow median longitudinal dark stripe ..... *marteri sogdianus*

11(9). Scutum with very narrow pale piliform scales on median area; lower proepisternal setae present; palpomere 5 not more than 0.5 length of palpomere 4 ..... *claviger*

– Scutum with narrow to moderately broad pale spatulate scales on median area; lower proepisternal setae absent; palpomere 5 longer than 0.5 length of palpomere 4 ..... *plumbeus*

12(2). Hindtarsomere 4 entirely pale-scaled; wing with white scales on veins M, CuA and 1A ..... *pseudopictus*

– Hindtarsomere 4 pale-scaled at apex only; wing with yellowish scales on veins M, CuA and 1A ..... *hyrcanus*

SUBFAMILY CULICINAE

KEY TO SPECIES OF *AEDES* AND *OCHLEROTATUS*

1. Some tarsomeres with rings of pale scales 2

– Tarsi without pale rings (some white scaling not arranged in rings may be present) 13

2(1). Hindtarsomeres with both basal and apical pale rings 3

– Hindtarsomeres with basal pale rings only 8

3(2). Abdominal terga with basal pale bands only 4

– Abdominal terga with median pale stripes, sometimes entirely pale-scaled 5

4(3). Wing entirely dark-scaled except for small white patch at base of costa 6

– Wing with numerous scattered pale scales 7

5(3). Scutum golden-scaled with narrow dorsocentral stripes of white scales; base of costa mostly dark-scaled; vein R with dark and pale scales ..... *Oc. caspius*

– Scutum with narrow to broad median golden-scaled stripe and white to creamy scales laterally; base of costa and vein R white-scaled, occasionally with few dark scales ..... *Oc. dorsalis*

6(4). Femora and tibiae with scattered pale scales; scutum predominantly golden-scaled; erect scales of head entirely or predominantly pale ..... *Oc. pulcritarsis*

– Femora and tibiae without scattered pale scales; scutum predominantly brown-scaled; erect scales of head entirely or predominantly dark ..... *Oc. berlandi*

7(4). Scutum mainly golden brown-scaled, without definite longitudinal stripes; metameron with patch of scales ..... *Oc. mariae*

– Scutum with submedian longitudinal stripes of white scales; metameron bare ..... *Oc. zammitii*

8(2). Hindtarsomeres with narrow basal rings, ring of hindtarsomere 2 ≤ 0.2 length of tarsomere; basal pale bands of abdominal terga indented or interrupted medially ..... *Ae. vexans*

– Hindtarsomeres with broad basal rings, ring of hindtarsomere 2 > 0.2 length of tarsomere; basal pale bands of abdominal terga not indented or interrupted 9

9(8). Pale scales of thorax and abdomen shining silvery white 10
– Pale scales of thorax and abdomen dull yellow and/or white 12

10(9). Scales of lateral and posterior scutal fossal and posterior dorsocentral areas silvery white, forming a lyre-shaped mark; scutum also with a pair of narrow longitudinal submedian stripes; clypeus with scales ..... *Ae. aegypti*
– Scales of posterior scutal fossal area dark; scutum with a rather broad median longitudinal pale stripe; clypeus bare 11

11(10). Median longitudinal line of pale scales extending to prescutellar area, continuous with pale prescutellar scales; lateral scutal fossal, antealar and supraalar areas with pale scales forming a more or less continuous line on lateral margin of scutum; metameron with patch of scales ..... *Ae. cretinus*
– Median longitudinal line of pale scales not extending to prescutellar area; lateral scutal fossal and antealar areas with dark scales only; metameron bare ..... *Ae. albopictus*

12(9). Abdominal terga with rather distinct narrow white or cream-coloured basal bands, sometimes very narrow or absent, and scattered pale scales posteriorly ..... *Oc. cantans*
– Abdominal terga with broader ill-defined yellowish-white basal bands and scattered pale scales posteriorly ..... *Oc. annulipes*

13(1). Abdomen with prominent shining silvery-white lateral patches; cerci short, scarcely visible 14
– Abdomen with lateral patches of dull yellowish or white scales; cerci long, plainly visible 15

14(13). Scutellum with narrow yellowish-white scales; metameron bare; abdominal terga with basolateral pale patches only ..... *Oc. geniculatus*
– Scutellum with broad white scales; metameron with patch of scales; at least some abdominal terga with complete basal pale bands ..... *Oc. echinus*

15(13). Dorsal area of postpronotum with decumbant narrow spatulate scales (mostly dark); scutum with submedian longitudinal dark stripes 16
– Dorsal area of postpronotum with narrow falcate scales (usually pale); scutum without distinct submedian longitudinal dark stripes 17

16(15). Basal pale bands of abdominal terga produced posteriorly in middle, posterior areas of terga with mixture of dark and pale scales; remigium of wing entirely pale-scaled ..... *Oc. refiki*
– Basal pale bands of abdominal terga produced medially to form longitudinal stripes, posterolateral areas of terga and remigium of wing entirely dark-scaled ..... *Oc. rusticus*

17(15). Mesopostnotum and lower area of metapleuron with scales; abdominal terga almost completely covered with pale scales, sometimes dark scales forming indistinct spots ..... *Oc. lepidonotus*
– Mesopostnotum and metapleuron without scales; abdominal terga usually with distinct basal pale bands 18

18(17). Lower mesepimeral setae absent; basal pale bands of abdominal terga distinctly narrowed medially, sometimes interrupted medially on posterior terga ..... *Oc. sticticus*

– Lower mesepimeral setae present; basal bands of abdominal terga more or less straight or only slightly narrowed medially, never interrupted medially on posterior terga 19

19(18). Hypostigmal area with patch of pale scales 20

– Hypostigmal area without patch of pale scales 21

20(19). Costa, subcosta and radius-one of wing speckled with pale scales; anterior surfaces of fore- and midfemora with numerous scattered pale scales ..... *Oc. cataphylla*

– Wing with pale scales restricted to base of costa; anterior surfaces of fore- and midfemora with few pale scales ..... *Oc. pullatus*

21(19). Anterior veins of wing speckled with pale scales; abdominal terga with mixture of dark and pale scales posteriorly ..... *Oc. detritus*

– Wing with pale scales confined to base of costa; abdominal terga entirely dark-scaled posteriorly 22

22(21). Lower proepisternal scales present; basal pale bands of abdominal terga narrowed medially ..... *Oc. punctor*

– Lower proepisternal scales absent; basal pale bands of abdominal terga more or less straight ..... *Oc. communis*

KEY TO SPECIES OF *COQUILLETTIDIA*

1. Proboscis entirely dark-scaled; wing uniformly dark-scaled ..... *buxtoni*

– Proboscis largely pale-scaled; wing with pale and dark scales ..... *richiardii*

KEY TO SPECES OF *CULEX*

1. Abdominal terga with apical pale bands or apicolateral pale patches 2

– Abdominal terga with basal pale bands or basolateral pale patches 5

2(1). Postspiracular and prealar scales present; palpomere 2 usually with pale scales (subgenus *Maillotia*) ..... *hortensis*

– Postspiracular and prealar scales absent (subgenus *Neoculex*) 3

3(2). Abdominal terga unbanded, with rather large lateral pale patches generally not visible in dorsal view; scutal scales small, dark, integument largely exposed ..... *martinii*

– Abdominal terga with narrow complete or incomplete (medially) apical pale bands; scutal scales large, pale, integument more or less completely covered 4

4(3). Apical pale bands of abdominal terga complete ..... *territans*

– Apical pale bands of abdominal terga weakly developed, interrupted or broken medially ..... *impudicus*

5(1). Proboscis shorter than forefemur; hindtarsomere 1 short, not more than 0.85 length of hindtibia (subgenus *Barraudius*) 6

– Proboscis as long or longer (usually longer) than forefemur; hindtarsomere 1 usually long, not less than 0.86 length of hindtibia (subgenus *Culex*) 7

6(5). Abdominal terga usually with longitudinal stripe of pale scales laterally, sometimes forming more or less well developed triangular patches at basal margins of terga ..... *modestus*
– Abdominal terga with pale-scaled spots basolaterally ..... *pusillus*

7(5). Hindtarsomeres with pale rings; wing with pattern of pale spots; lower mesepimeral seta absent ..... *mimeticus*
– Hindtarsomeres without pale rings; wing without pattern of pale spots, entirely dark-scaled or with some pale scaling not arranged in distinct spots; lower mesepimeral seta(e) present 8

8(7). Postspiracular and prealar scales present 9
– Postspiracular scales absent; prealar scales present or absent 10

9(8). All tibiae with anterior pale stripes; prealar and upper and lower mesokatepisternal scale-patches confluent; basal pale bands of abdominal terga produced posteriorly in middle ..... *theileri*
– Fore- and midtibiae without pale stripes (midtibia sometimes with an incomplete stripe); prealar and upper and lower mesokatepisternal scale-patches separate; basal pale bands of abdominal terga not produced posteriorly in middle ..... *perexiguus*

10(8). Prealar scales present 11
– Prealar scales absent 12

11(10). Wing with short line of pale scales at base of costa; scales of forecoxa all pale; frequently 2-4 lower mesepimeral setae ..... *laticinctus* (in part)
– Wing entirely dark-scaled; forecoxa with some dark scales; usually one lower mesepimeral seta ..... *torrentium* (in part)

12(10). Two to 4 lower mesepimeral setae present; scales of forecoxa all pale; wing with short line of pale scales at base of costa; proboscis all dark or faintly pale beneath ..... *laticinctus* (in part)
– Only one lower mesepimeral seta normally present; forecoxa with some dark scales; wing entirely dark-scaled; proboscis usually distinctly pale beneath in middle 13

13(12). Cell R_2 more than 4.0 length of vein R_{2+3}; integument and scales between supraalar and posterior dorsocentral setae usually noticeably darker than surrounding integument and scales, appearing as ovoid spots ..... *pipiens*
– Cell R_2 less than 4.0 length of vein R_{2+3}; integument and scales between supraalar and dorsocentral setae not appreciably darker than surrounding integument and scales ..... *torrentium* (in part)

KEY TO SPECIES OF GENUS *CULISETA*

1. Femora and tibiae with speckles, spots and/or stripes of pale scales 2
– Femora and tibiae dark-scaled 5

2(1). Wing entirely dark-scaled; metameron without scales ..... *fumipennis*
– Wing with pale scales on anterior veins; metameron with small patch of scales 3

3(2). Costa of wing completely pale-scaled; lateral margin of antennal scape, posteroventral area of cervix and lower proepisternum with scales ..... *longiareolata*

– Costa speckled with pale scales; antennal scape, cervix and lower proepisternum without scales 4

4(3). Relatively dark mosquito; pale scaling of abdominal terga limited to basal bands and median stripe on tergum II; CuA entirely dark-scaled ..... *annulata*

– Relatively pale mosquito; posterior areas of abdominal terga with variable amount of pale scaling, ranging from pale speckling to completely pale; CuA speckled with pale scales ..... *subochrea*

5(1). Tarsi entirely dark-scaled; postspiracular area and metameron with small patch of scales ..... *glaphyroptera*

– Tarsi with basal pale marks; postspiracular area and metameron bare ..... *morsitans*

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