A Review of *Anopheles maculipennis* Complex in North Africa

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Abstract: The identification of species that belong to Maculipennis complex is very difficult because of the morphological similarity within this group. The molecular identification of species belonging this complex showed the existence of a single species called *Anopheles labranchiae* in Tunisia, Algeria and Morocco. This is important information for malaria control in the North Africa. The arid climate of Lybia excluded the members of Maculipennis complex except *An. labranchiae* and *An. sacharovi*. In the neighboring country, no species of this complex has been identified in Egypt. The accurate and correct identification of mosquito vectors is very important for the implementation and development of vector control strategies.

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1. Introduction:

It is already confirmed that the *Anopheles* species play unequal roles in the transmission of malaria to humans. Some species are not involved in the transmission of this parasite because of their vector incompetency. That's why the study of the taxonomy of vectors has the same importance as the parasitological study of malaria parasites (Artemiev, 2001).

Anopheles maculipennis is the first complex of mosquitoes' species identified in Europe and in the Middle East as malaria vector (White, 1978; Ribeiro et al., 1996). Actually, the *An. maculipennis* complex consists of 12 members who are *An. atroparvus, An. beklemishevi, An. labranchiae, An. maculipennis, An. martinus, An. melanoon, An. messeae, An. sacharovi, An. persiensis, An. daciae, An. lewisi* and *An. artemievi* (White, 1978; Ribeiro et al., 1996; Linton et al., 2002a; Sedaghat et al., 2003a; 2003b). Just six species that belonging to this complex and which exist in Europe, Asia, and North Africa: *Anopheles labranchiae, An. atroparvus, An. messeae, An. sacharovi, An. maculipennis*, and *An. melanoon.*

The distinction between the various complex species is very difficult if not impossible given their morphological similarities. Except for *An. sacharovi*, these species are morphologically unidentifiable whether in adult or larval stages (Sedaghat et al., 2003a; Nicolescu et al., 2004; Linton et al., 2002b; Patsoula et al., 2007). Other authors have suggested the possibility of morphological identification of certain species (Doosti et al., 2006; 2007).

Ecological, physiological and biochemical studies were carried out in order to identify the different species of *An. maculipennis* complex (Hackett et al., 1935; Deruaz et al., 1991; Kitzmiller et al., 1967; Stegnii, 1987; Phillips et al., 1990; Bullini et al., 1978; Korvenkontio, 1979). Recently, molecular studies have been introduced to achieve this goal (Paskewitz et al., 1993; Collins et al., 1996; Marinucci et al., 1999; Proft et al., 1999, Di Luca et al., 2004; Kampen, 2005a; 2005b).

Proft et al. (1999) have recently developed a diagnostic PCR system able to identify seven species of *An. maculipennis* sibling species that exist in Europe, Asia and northern Africa: *An. maculipennis, An. sacharovi, An. melanoon, An. atroparvus, An. labranchiae* and *An. messeae*.

The objectives of this manuscript are to review the status of *An. maculipennis* complex in North Africa countries. The available published reports were collected and reviewed.

2. *Anopheles maculipennis* complex in North Africa countries (Figure 1):

The morphological identification of the species that belonging to the Maculipennis complex is very difficult because of the similarity that exists within this group (Romi et al, 2000). *Anopheles labranchiae* is the only species molecularly identified in Tunisia and belonging to this complex. The proportion of this species already identified by different authors and based on morphological characteristics can be reported correctly in this country (Chahed et al., 2001; Krida et al., 1998). This species is mainly found in northern Tunisia and they dominate by their densities the other species of *Anopheles* (Brhunes et al., 2000; Tabbabi et al., 2015).

Molecular studies of anopheline specimens showed that *An. labranchiae* is the only species of *An. maculipennis* group in eight provinces of Morocco during the period of mosquito collections. These results confirm previous studies carried out in the same area. Faraj et al. (2004) showed during the study of the ITS2 sequences of Maculipennis complex that *An. labranchiae* is the only species that exists in Morocco. Recently Laboudi *et al.* (2011) have found the same results using mtDNA sequences (COI barcode region) of *An. maculipennis s.l.*

D'Anfreville was the first author who described *An. maculipennis* complex in Morocco (D'Anfreville, 1916). Ever since, many authors have mentioned their existence throughout Morocco (Seguy, 1930; Bates, 1940; Gaud et al., 1949; Guy et al., 1976; White, 1978; Himmi, 1991; Faraj et al., 2008, 2010). Old studies have revealed the existence of two sibling species of this complex: *Anopheles sicaulti* (Roubaud, 1935) and *An. labranchiae* (Guy et al., 1976). *Anopheles sicaulti* was described by Sicault, the first who showed similarity with *An. labranchiae* based on the morphology of their eggs (Roubaud, 1935). Four years later, Bates (1940) has synomonized both species. Others have considered both species as varieties (Viamonte, 1949; Senevet & Andarelli, 1956). Recently, the two varieties were recollected in Morocco and they showed that *An. sicaulti* was just a geographic variety of *An. labranchiae* (Zulueta et al., 1983, laboudi et al., 2011).

In Morocco, *An. labranchiae* is distributed on large surfaces and its distribution covers almost all of Morocco (Anfreville, 1916; Delanoe, 1917; Charrier, 1924; Séguy, 1930; Sicault et al., 1935; Langeron, 1938; Callot, 1940; Ristocelli, 1946; Bonjean, 1947; Gaud, 1953; Guy, 1963; Trari and Himmi, 1987; Himmi, 1991; Faraj et al., 2004). Its density is very high in the north where it presents the dominant species compared to the other *Anopheles* (Benmansour et al., 1972; Gaud et al., 1949). This species is mostly associated with the rice growing areas that occur between July and September (Faraj et al., 2008). With the exception of a single report melanic (*An. melanoon*) form eggs (Sergent, 1939), only *An. labranchiae* is present in Algeria (Sergent, 1937; 1939; Senevet and Andarelli, 1961). This species is widely distributed in the north of the country (Séguy, cited in Senevet and Andarelli, 1956).

The ecological constraints in Libya and the arid climate excluded all members of Maculipennis Group except *An. labranchiae* and *An. sacharovi* which were suggested by La Face, (1937). The only existing record of *An. sacharovi* was based on the morphological identification of two instars larvae (Goodwin and Paltrinier, 1959). Other studies have been carried out on adults since the possibility of morphological distinctions of *An. labranchiae*, and *An. sacharovi*. In contrast to the Maghreb where it was the main vector of *Plasmoduim vivax*; *An. labranchiae* is important just in some restricted areas in Libya (Touarga in Tripolitania). In the neighboring country, no species of *An. maculipennis* group has been identified in Egypt.

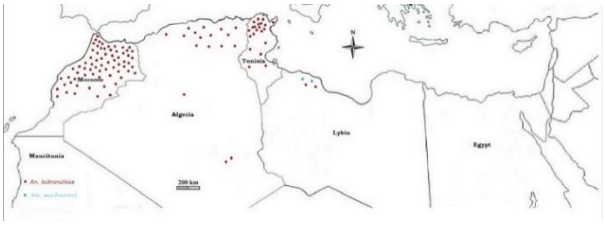

Figure 1. *Anopheles maculipennis* complex in North Africa countries (Brunhes et al., 2000; Tabbabi et al., 2015; Faraj et al., 2010; Ramsdale, 1990; Kenawy, 2015; WHO, 2014).

3. Conclusion:

Despite the recent detection of *An. labranchiae* and *An. sacharovi* in northern Africa, the situation is becoming alarming. The epidemiology of malaria must be well studied by recent molecular biology techniques to avoid misidentification of *Anopheles* and to understand of parasite/vector relationship.

Conflicts of Interest:

Authors declared no conflicts of interest.

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