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THE NOMENCLATURE AND TAXONOMIC STATUS OF THE MOSQUITOES OF THE ANOPHELES MACULIPENNIS COMPLEX¹

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The mosquitoes of the *Anopheles maculipennis* group have been the subject of many hundreds of papers since the publication, in 1920 and 1921, of the theories of Roubaud, Wesenberg-Lund, and Grassi to account for the absence of malaria in regions where *maculipennis* is abundant. Roubaud thought that there were two "physiological races," one adapted to feeding on man, the other on large domestic animals. Wesenberg-Lund thought that in Denmark the species had changed its food habits, becoming adapted to large domestic animals. Grassi, like Roubaud, thought there was a "biological race" that did not bite man. The search for the explanation of this problem of "anophelism without malaria" has made *maculipennis* one of the most thoroughly studied of all insects, and has uncovered a situation that is of considerable general biological interest from the point of view of the "species problem."

The history and bibliography of the basic work on the *maculipennis* problem has been covered in a paper by Hackett and Missiroli (1935). All students who have interested themselves in the problem seem to be agreed that the mosquitoes formerly included under the single taxonomic concept of "*Anopheles maculipennis*" form a group of more or less independent populations distinguished by various physiological and morphological characters. Beyond this fundamental point, however, there is little agreement. The various populations have been called "races," "biological races," "varieties," "biotypes," "subspecies," "species," and some twenty latinized names have been proposed for them. The object of the present paper is to review this situation from the points of view of taxonomy and evolution, and to determine to what category in the taxonomic hierarchy these populations should be assigned and what Latin names are available for denominating them.

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We shall first consider the definitions and general usage of the various taxonomic categories to which these populations have been at one time or another assigned (variety, species, etc.), and review very briefly the characteristics of the *maculipennis* populations in the light of these definitions. We shall then give brief histories of the various names that have been proposed in the synonymy of *Anopheles maculipennis* in the wide sense, and from these attempt to determine which names should be used for the various populations.

DEFINITIONS OF CATEGORIES

The following review is based largely on the chapter in Robson and Richards (1936) entitled "The categories of variant individuals." The names are taken up in alphabetical order.

Biotype.—Diemer and van Thiel (1936) have proposed that the *maculipennis* populations should be called biotypes; and they further organize the populations into "geobiototype-circles" more or less by analogy with the "Rassenkreis" principle. They define a biotype as "the organic structure type of all specimens, which have the same structure in the same stage of life and phaenotypically show only inconstant differences, which live in a coherent territory or in the same conditions of life, which in nature mate spontaneously and produce a perfectly fertile progeny."

The difficulty with this is that Diemer and van Thiel have taken a rather well-established term and redefined it to fit a particular case. The term "biotype" was apparently first proposed by Johannsen, and it is generally used to denote the least definable category of variant individuals. Du Rietz, for instance (1930, p. 340), has defined a biotype as a "population consisting of individuals with identical genotypical constitution." Thus, defined, biotypes are probably limited to asexual organisms and laboratory pure lines; but the term is sometimes applied to wild strains of sexual organisms, and it is a useful theoretical category (Robson and Richards, 1936, p. 72; Dobzhansky, 1937, p. 320). In this sense each of the recognized *maculipennis* populations seems to be composed of many biotypes, since diverse genetic strains appear to exist. This is most strikingly shown by the variation in larval pattern found associated with any particular egg-type, variation that seems to be genotypic rather than phenotypic.

Form.—The writer has used this term for the *maculipennis* populations in previous papers, considering that it conveyed no special implications concerning the status of the populations thus denominated. If the various "categories of variant individuals" are to be given more or less precise definitions, it would certainly be convenient to have some general term for populations or variations of undetermined status, and "form" might easily be reserved for this purpose. The same, of course, might be said of "variety," but variety to the writer, conveys a definite sub-specific status that form does not. Form does, perhaps, imply a mor-

phological basis of separation, and in that way its use in situations like that presented by *maculipennis* is unfortunate. Du Rietz (1930, p. 342) has attempted to define form precisely as "a population of one or several biotypes occurring sporadically in a species-population (not forming distinct regional or local facies of it) and differing from the other biotypes of this species population in one or several characters." In that sense, the term "form" is, of course, quite inapplicable to the *maculipennis* populations.

Race.—From the very beginning of their study, the *maculipennis* populations have been called races, biological races, or physiological races more often than anything else. The term race is very often employed in biological literature, but it seems rarely to be defined. For the most part it is used as an exact equivalent of the more technical term "subspecies," and it is, in fact, defined in the dictionary (Webster) as "a natural group inferior in rank to a species." Like subspecies, the term "race" usually has a geographical connotation, and it is on "geographical races" that Rensch (1929) has constructed the "Rassenkreis" principle. Since the *maculipennis* populations are not always characterized by separate geographical ranges, they cannot be considered to be "geographical races," nor can the complex be considered to form a "Rassenkreis" in the sense of Rensch, although as Diemer and van Thiel have pointed out, some of the populations show "Rassenkreis" characteristics.

The term "biological race" has been defined by Thorpe (1930, p. 177), in his careful review of the subject, as follows: "A biological race may be said to exist where the individuals of a species can be divided into groups, usually isolated to some extent by food preferences, occurring in the same locality and showing definite differences in biology, but with corresponding structural differences, either few or inconstant, or completely absent." This definition would have applied admirably to the case of *maculipennis* at the beginning of its study; but the mass of evidence now accumulated seems to point to a much more profound cleavage between the *maculipennis* populations than would be indicated by such a definition. Most "biological races," in the sense of Thorpe, occur in phytophagous or parasitic organisms where a split in a species-population between two different hosts gives some chance of physical separation of the two resulting populations. The great divergence in habit between larva and adult in mosquitoes makes it difficult to conceive how the host association of the adult could result in physical (and subsequent physiological) separation in populations except where the alternative hosts belonged to separate habitats: and the habitat of man and his domestic animals is the same. The differences in the habits of the adults and larvae of the various *maculipennis* populations are relative, and it seems to the writer that they are much more readily explained as a *result* of the cleavage in the original population than as the *cause* of such cleavage. Any attempt at explaining the *maculipennis* populations in terms of biological races associated with different hosts is further complicated by the presence of at least seven such populations, although the only host difference so far suggested is between man and his domestic animals.

The term "physiological race" I take to be a simple synonym of "biological race."

Species.—Dobzhansky (1937, p. 306) has aptly pointed out that "in most animal and plant groups, except in so-called difficult ones, the delimitation of species is subject to no dispute at all." Yet no attempt at framing a definition of the term has met with any great success or general acceptance. This is partly due to the fact that although our knowledge of the vast majority of animal species is purely morphological, we mostly attempt to frame our definitions in physiological terms; and it is probably also partly due to the great variations in the behavior of organisms, which may mean that the characteristics of "species" in one group are different from those in another. The difficulty of framing a general definition, however, seems hardly a good argument for not defining the usage of the term for a particular group of animals. It is obviously out of the question to study the physiology of every putative species, to determine whether its characteristics fit those of a definition, and systematists will probably always continue to rely on analogy and inference—the inference that the behavior of an animal is different because its structure is different—in classifying their specimens. But since mosquitoes as a whole are probably the best known of all insect families, they might well serve as a basis for a careful study of the "species problem": of the nature of the physiological differences apt to be associated with differences in morphology.

Four definitions of species have been selected for consideration:

du Rietz (1930, p. 357): "The smallest natural populations permanently separated from each other by a distinct discontinuity in the series of biotypes, are called species. A species thus is a population consisting . . . of many sexually propagating biotypes forming a syngameon separated from all others by more or less complete sexual isolation or by comparatively small transitional populations."

Bates (1935, p. 70): "The general concept may be defined as a population or group of populations separated from other similar populations by some physiological barrier, which prevents fusion, and distinguishable by some heritable morphological characteristic."

Dobzhansky (1937, p. 312): ". . . to define species as that stage of evolutionary process at which the once actually or potentially interbreeding array of forms becomes segregated in two or more separate arrays which are physiologically incapable of interbreeding."

Ginsburg (1938, p. 260): ". . . it is proposed tentatively to limit the designation of species and its subdivisions as follows: other things being equal, a given population is to be considered . . . a full species (with respect to another closely related population) when the degree of intergradation is not more than 10 per cent."

Ginsburg's definition is introduced as an example of an attempt to find an objective yardstick that can be used by taxonomists in their daily museum work. The common denominator of the other three definitions, and of practically all attempts at definition that have been made, is *sexual isolation*. The question of sexual isolation has been discussed at some length in the books by Robson (1928), Robson and

Richards (1936), and Dobzhansky (1937). In the case of free-living animal populations which are found in the same habitat at the same time, the presence or absence of sexual isolation can presumably be inferred from the morphological variation, by the presence or absence of a "distinct discontinuity in the series of biotypes." It is, of course, theoretically possible that two sexually isolated populations could occur in the same habitat without having any correlated morphological distinctions; but it would be very difficult to recognize such populations. The study of *Anopheles maculipennis*, for instance, made little progress until morphological distinctions were found. In comparing two populations from widely separated habitats or regions, we can usually only infer whether sexual isolation would be present or not, since the populations are already isolated by physical barriers. Most of the difficulties in species classification, in fact, arise from this latter case. It is not always possible to demonstrate sexual isolation by laboratory experiments, since the isolating mechanism in nature may depend on behavior patterns which are interrupted or lost in the laboratory.

It seems to the writer that the *maculipennis* populations, in the light of these definitions, must, in part at least, be considered to be "species." The reasons for this will be reviewed in a later section.

Subspecies.—The term "subspecies" is used in the taxonomy of the vertebrates and the Lepidoptera to designate a geographically defined and morphologically distinguishable population. The theory behind this usage is that it is only through geographical separation that a single animal population can become divided into two or more populations sufficiently isolated from one another to permit divergent evolutionary trends to set in. The evidence for this in the higher vertebrates and the Lepidoptera seems to be overwhelming (for a thorough review, see Jordan, 1905). Most attempts at formal definition of subspecies include this geographical concept: e. g., du Rietz (1930, p. 354), "A subspecies is a population of several biotypes forming a more or less distinct regional facies of a species."

It seems to the writer, however, somewhat presumptive to limit the general use of the term "subspecies" to populations definable in geographical terms, and in his review of the taxonomic units in Lepidoptera (Bates, 1935) he proposed to apply it to "any partially independent population considered to represent an evolutionary stage in the development of species." His idea was further to classify subspecies according to the isolating factors presumed to be in operation—geographical, ecological, and so forth. Remarkably little is known about the possible rôle of these isolating factors in the process of speciation in mosquitoes, although they would seem to be an almost ideal group for such study, because their general biology has been the subject of much investigation, and because many species can easily be kept for study as laboratory colonies. It seems quite possible that the most significant types of morphological and physiological variation in mosquitoes may be found to be correlated with geographical factors, as in the vertebrates and Lepidoptera; and if this is found to be the case, it should certainly be reflected in the nomenclatorial system.

Variety.—The *maculipennis* populations have been called varieties almost as frequently as races, and the two terms are alike in that they are non-technical English words with many connotations but without any very precise or generally accepted usage. In the Diptera the term "variety" is very generally used for any variant individuals that are not considered to represent "distinct species," and the use of the term for mosquitoes is simply a carry-over from this general practise of dipterists. This usage seems to be the result of the fact that, outside of *Drosophila*, practically no study of subspecific variation has been made in the Diptera, and most groups of flies are really so little known that such a study would hardly be profitable. The term "variety" is used in many invertebrate groups in this same sense, and Bequaert (quoted by Robson and Richards, 1936, p. 67) has defended this usage on the grounds that the word is "neutral," i. e., without any presumption as to the true status of the units as "geographical races," "individual aberrations," or "elementary species." In this sense the term is very useful, particularly if it is recognized as a sign that "more information is needed."

THE MACULIPENNIS POPULATIONS AS SPECIES

It may be worth while to recapitulate the points of difference between the *maculipennis* populations which seem to indicate a specific status. (The nomenclature used here is that of Hackett and Missiroli, 1935, and Bates and Hackett, 1939.)

MORPHOLOGICAL

Eggs.—We have found seven distinct types of eggs in the material that we have studied (Bates and Hackett, 1939, p. 1556) and in only two cases have we found intergrades and difficulty in classification: *melanoon* vs. *subalpinus*, and *typicus* vs. *messeae*. In the first of these two cases the distinction seems to be purely geographical, and eggs from intermediate geographical regions are intermediate in character, which would seem to indicate that the difference between the types was *subspecific*. In the second case the confusion seems to be due to a phenotypic variation (due to temperature) which results in *typicus* eggs at certain times of year that are very similar to the eggs of *messeae*. In general we have found the egg pattern and structure to be the most reliable and useful method of separating the *maculipennis* populations: and all of the other characters that have been found seem definitely to be correlated with these egg differences.

Larvae.—The branching of the antepalpal hair of the fourth and fifth abdominal segments seems to be characteristic for each population (Bates, 1939c), and it is often possible to identify individual larvae with some certainty (e. g., in Albania).

Adults.—The adults of *sacharovi* are readily distinguished from those of the other egg types by several characters (Corradetti, 1934). Yet *sacharovi* is an integral part of the *maculipennis* complex, as is shown by the results of hybridization experiments (Bates, 1939). Differences have been found in the male genitalia in the case of some of the pop-

ulations (Shute, 1935). Statistical differences in size, and in the maxillary index have also been found (Weyer, 1935).

PHYSIOLOGICAL

Sexual behavior.—As far as we have been able to study it, the epigamic behavior of the adults seems to be different in each population (Bates and Hackett, 1939, p. 1562) and the differences are of the same order of magnitude as those found between mosquito "species" in general.

Hybridization.—In the cases in which it has been possible to study hybrids, various degrees of sterility have been found in the F_1 generation (Bates, 1939), and in no case studied have the populations been found to be completely fertile *inter se*.

Physiological differences, correlated with the egg types, have been found in the larval ecology (Bates and Hackett, 1939), in larval survival in salt solutions (Bates, 1939b), in hibernation of the adults (Weyer, 1937), in the food reactions of the adults (van Thiel and Bevere, 1939). The *maculipennis* populations, in short, seem to show all of the physiological differences that one would expect to find in any group of related *Anopheles* species selected for study.

If we re-examine the four definitions quoted for "species," we find that the *maculipennis* populations have to be considered as "distinct species," in part at least, according to any of the four. They seem to be sexually isolated, and there are morphological differences in both egg and larva; only the adult is difficult to identify, and this is not true of one form (*sacharovi*).

The curious conservatism of the *maculipennis* adults under these circumstances deserves remark. Apparently morphological differences, although usually supposed to be correlated with "specific" physiological differences, are not necessarily present. One might suppose that the *maculipennis* populations are comparatively recently evolved species—and this is the usual supposition. But we know that in some cases insects have retained an identical morphological structure through long periods of geological time (e. g., the case of ants from Lower Oligocene amber identical in structure with ants living today. Wheeler, quoted by Robson and Richards, 1936, p. 132), and we know that mosquitoes are a comparatively ancient and conservative group of insects (Edwards, 1932, p. 6). The presence of mosquitoes with the *maculipennis* structure in America, Asia, and Europe would in itself indicate an ancient type, since there is no reason to suppose that this distribution has been brought about by man. It seems to the writer that it is very possible that the divergences in the *maculipennis* populations may have arisen in the geological past, and that perhaps originally each of the populations that we can now recognize occupied a distinct geographical range, the ranges merging only after the populations had diverged sufficiently to enable them to retain their identity when living together. At any rate, it would be very rash to use the present distribution of the *maculipennis* populations as an argument against the rôle of geographical isolation in the formation of species.

But after deciding that the *maculipennis* populations are species,

there remains the problem of nomenclature. Swellengrebel and de Buck long ago concluded that these mosquitoes were "species," but at the same time they thought that it would be a mistake to apply ordinary specific nomenclature to them. Their reasons (1938, p. 89) are weighty, and the writer was for a long time in agreement with them. The nomenclature of mosquitoes is already very involved and confusing, and no step likely to add to the confusion should be taken without careful consideration. Linnean nomenclature is essentially a tool—a fundamental tool in biological study—and its use depends on museum procedures which are concerned primarily with adult morphology. The *maculipennis* populations present well-defined morphological differences in the egg, but the study of these differences involves essentially biological procedures with the living animals: the eggs cannot be permanently preserved, and thus there is no possibility of "type specimens," and the comparison of material from different regions is very difficult. We might well restrict the Linnean nomenclature to cases that can be studied by museum procedures, and keep in mind that our Linnean species are, in part at least, only guide cards for filing our information.

The difficulty with this is that we are apt to forget that "*Anopheles maculipennis*" is an arbitrary concept not comparable, for instance, with "*Anopheles superpictus*." And it is very difficult to call "*atroparvus*" a variety of "*Anopheles maculipennis*" without beginning to think in terms of "elementary species" when, as we have seen, there is considerable evidence that the adjective "elementary" is entirely out of place. Swellengrebel and de Buck worked with a limited fauna with only two *maculipennis* populations, and their intention was to abandon Latin names for these populations altogether. This works admirably in the Netherlands, where they call their two populations "longwings" and "shortwings," but an extension of this system to the entire *maculipennis* complex would involve either the invention of a new set of names, or the removal of the present names from the system of zoological nomenclature; and neither of these alternatives is apt to gain very general acceptance. The present names have all been proposed in a Latin form as bona fide "subspecies" or "varieties," and while it is easy to shift such names from one category to another in the system, it is impossible to remove them once proposed—they would always remain in the synonymy.

If we give these *maculipennis* populations names like those we apply to any other mosquito species, it seems to the writer that the whole situation becomes much more intelligible. Swellengrebel and de Buck argue that people expect *Anopheles maculipennis* var. *atroparvus* to act the same way in, say, Hungary that it acts in the Netherlands, and that when a different behavior is found in Hungary, this is considered to throw doubt on the Netherlands observations. But would this be true if we thought in terms of "*Anopheles atroparvus*"? We are not surprised to find different behavior on the part of *Anopheles superpictus* in, say, Albania and Cyprus; and the difficulty in the case of *atroparvus* is not that we have fixed its attributes by giving it a Latin name, but that we are apt to restrict those attributes too narrowly because we have put the name in the wrong category.

LIST OF AVAILABLE NAMES IN THE MACULIPENNIS GROUP

alexandrae (*shingarevi*) Shingarev, 1928.

Described as a subspecies of *maculipennis* on the basis of the male hypopygium; from the Vladimir and Penza Governments. Martini (1931, p. 163) gives a translation of the original description. It is generally listed as a synonym of *maculipennis* (Edwards, 1932; Zhelokhovtzev, 1937).

atroparvus van Thiel, 1927.

Described as a "variety" of *maculipennis* on the basis of the smaller size, larger number of maxillary teeth and dark color in comparison with the "typical" form found in Holland. This is the "shortwings" of Swellengrebel and de Buck. The type locality is Bolsward (Friesland). The "typical" form of van Thiel, the "longwings" of Swellengrebel *et. al.*, is the *messeae* of other authors.

aztecus Hoffmann, 1935.

Described as a subspecies (trinomial) of *maculipennis* on the basis of a number of morphological characters of larva and adult, which do not, unfortunately, allow comparison with the European forms. Hoffmann distinguishes two American "races," his *aztecus* and *occidentalis* Dyar and Knab; and in his 1936 paper he has given an extensive bibliography of these two names. The type locality of *aztecus* is the Valley of Mexico.

basilei Falleroni, 1932.

Proposed by Falleroni as a varietal name for the *maculipennis* laying eggs with two simple bars, which he and others had previously considered to be the "typical" form. The type locality of the name would presumably be Central Italy.

cambournaci Roubaud and Treillard, 1936.

Described as a variety of *maculipennis* from Portugal: like *atroparvus* but differing slightly in egg pattern and in behavior.

elutior Martini, 1931.

Described as a variety of *Anopheles elutus* from Turkestan, the description being based entirely on adult characters.

elutus Edwards, 1921.

Described as a new species of *Anopheles*, based on characters of the adult and egg, on material from various parts of the Near East, the type being from Kishon, Palestine. Edwards (1926) in the Italian edition of his revision of the Palearctic mosquitoes, placed this name in the synonymy of *sacharovi* Favre; but other authors have considered Favre's name to be of uncertain application, and have preferred to retain *elutus* (Martini, 1931; Hackett and Missiroli, 1935).

fallax Roubaud, 1934.

Described as a race of *maculipennis* from Normandy, based principally on characters of the egg. It is apparently a geographical or local form of *atroparvus*.

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lewisi Ludlow, 1920.

Described as a new species of *Anopheles* from Siberia. It was placed in the synonymy of *maculipennis* by Dyar, and seems not to have been critically examined since.

maculipennis Meigen (1818, Syst. Besch., I, p. 11; not seen).

By a process of elimination this name (*sensu stricto*) has come to be applied to the mosquito laying grey eggs with two simple bars: the *typicus* of Hackett and Missiroli, *basilei* of Falleroni. Hackett and Missiroli (1935, p. 93) give an historical sketch of the restricting process.

martinius Shingarev, 1926.

Described as a new species of *Anopheles*, based on characters of the adult, from Turkestan. Martini (1931, p. 164) suggested that it might be a variety of *Anopheles algeriensis*, but Zhelokhovtzev (1937), after an examination of the type, concluded that the name is a synonym of *sacharovi*.

melanoon Hackett, 1935.

Described in the paper by Hackett and Missiroli (1935) as a variety of *maculipennis*, based on characters of the egg. The distribution is there stated to be "north Italy, Tuscany, the region of Strasbourg, and the northeastern coast of Spain from Barcelona to Valencia." Later Hackett and Lewis (1935) in describing *subalpinus*, restricted the range of *melanoon* to Italy. Viareggio is specifically mentioned in the original description of *melanoon*, and perhaps this can be taken as the type locality.

messeae Falleroni, 1926.

Described as a variety of *maculipennis* based on egg pattern; probably, as in the case of *labranchiae*, the Pontine Marshes should be considered as the type locality.

occidentalis Dyar and Knab, 1906.

Described as a species of *Anopheles* from the western United States (type locality, Stanford University, California). Dyar himself subsequently considered this form to be identical with the European *maculipennis*.

pergusiae Missiroli, 1935.

Described as a variety of *maculipennis* from Sicily, based on characters of the egg. Missiroli has subsequently concluded that these eggs were merely aberrant examples of *labranchiae*, the common form in Sicily.

relictus Shingarev, 1928.

Described as a new species of *Anopheles* from Usbekistan, based on characters of the adult. Martini (1931, p. 146) gives a translation of the original description; both he and Edwards (1932) consider it to be a synonym or variety of *sacharovi*.

sacharovi Favr, 1903.

Described as a new species of *Anopheles* from the province of Elisabethopol (Caucasus). Edwards (1926, p. 271) has given a translation of the original description; he states that "it seems absolutely certain that this description corresponds to that of *A. elutus*. . . . I have examined many specimens from regions very close to that reported by Favr."

selengensis Ludlow, 1920.

Like *lewisi*, this was described as a new species of *Anopheles* from Siberia; and has subsequently been carried in the synonymy of *maculipennis*.

sicaulti Roubaud, 1935.

Described as a variety of *maculipennis* from Morocco, based on characters of the egg and adult behavior. It is very similar to *labranchiae*.

subalpinus Hackett and Lewis, 1935.

Described as a variety of *maculipennis* from Spain, northwest Italy, and Albania; based on characters of egg, larva, and adult genitalia. The statistics for larval variation given in the original description are based on Albanian material, hence this may be taken as the type locality.

typicus Hackett and Missiroli, 1935.

The first usage of this name in a Latin form seems to be in the 1935 paper of these authors. It is, by definition, an absolute synonym of *maculipennis* in the strict sense (*basilei*).

PROPOSED CLASSIFICATION OF THE MACULIPENNIS GROUP

Our own studies have been limited to the fauna of Albania and Italy, and consequently the following classification, especially in so far as it involves the Russian and American faunas, is purely conjectural.

Anopheles maculipennis Meigen

Syn.: *typicus* Hackett and Missiroli; *basilei* Falleroni.

This species is widely distributed in Europe, and it seems in general to be quite constant in its characters. To avoid possible confusion, the species could be referred to as "*maculipennis* s. s.," and the complex as the "*maculipennis* group."

Anopheles messeae Falleroni

The range of *messeae* corresponds quite closely with that of *maculipennis*, except that it does not extend as far south (e. g., it apparently does not occur in Greece). Southern records in the literature are apt to be unreliable, owing to confusion with *melanoon* and *subalpinus*.

Anopheles melanoon melanoon Hackett

Since *melanoon* is an older name than *subalpinus*, it must be used for the species, although *subalpinus* is a much more widely distributed form,

and the *melanoon* population is presumably derived from *subalpinus* rather than vice-versa. *Melanoon* seems to be limited to the Italian peninsula.

***Anopheles melanoon subalpinus* Hackett and Lewis**

This form is found in Spain, northern Italy, and throughout the Balkans. The only known distinction between *melanoon* and *subalpinus* is in the egg, but the normal eggs are strikingly different, and intergrades seem to occur only in central Italy.

***Anopheles labranchiae labranchiae* Falleroni**

Syn.: *pergusiae* Missiroli; ? *sicaulti* Roubaud.

Labranchiae and *atroparvus* are much more distinct than *melanoon* and *subalpinus*, but at the same time they do not seem to be as distinct as, say, *subalpinus* and *maculipennis*, and it seems to the writer that this difference in level is best shown by making the two forms subspecies in the same "Rassenkreis." The ranges, as far as we know, overlap only in the vicinity of Foggia (Italy), and there no transitional forms have been found. The two subspecies are, however, partially fertile in the laboratory (Bates, 1939), and a hybrid colony was maintained in the Albanian laboratory for some time. *Labranchiae* seems to be limited to Italy, Spain, certain Mediterranean Islands, and north Africa.

***Anopheles labranchiae atroparvus* van Thiel**

Syn.: *fallax*, Roubaud; *cambournaci* Roubaud and Treillard.

It seems likely that at most Roubaud's names indicate "local races" or perhaps even "biotypes" in the strict sense. *Atroparvus* is very widely distributed in central Europe, and it is in part broken into local populations by the discontinuity of its habitats, so that it is not surprising that many local variations should be found.

***Anopheles sacharovi* Favr**

Syn. (all questionable): *elutior* Martini; *elutus* Edwards; *martinius* Shingarev; *relictus* Shingarev.

This is a Near Eastern form that has been studied carefully only in the vicinity of the Mediterranean coast: it is very possible that in other parts of its range it has broken up into distinguishable subspecies.

***Anopheles occidentalis* Dyar and Knab**

It seems very likely that the American representatives of the *maculipennis* group may include several subspecies, or even species (*aztecus* Hoffmann). Perhaps *quadrifasciatus* Say should be considered as belonging to this group.

The following names must be considered as "of uncertain status": *alexandrae* Shingarev, *lewisi* Ludlow, *selengensis* Ludlow.

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THE PRINCIPLES OF HEREDITY, Second Edition, by LAURENCE H. SNYDER. Pages xv+452, 164 text figs. 1940. Published by D. C. HEATH AND COMPANY, 285 Columbus Ave., Boston, Mass. Price \$3.50.

The new edition of this well-known and highly successful textbook appears in very different covers but with no important change in format.

The most valuable addition is Chapter XIX on Giant Chromosomes, a subject so recently developed that it has not received adequate treatment in textbooks of genetics. Other additions are a new nomenclature for modified two-factor ratios, a discussion of the chi-square concept, and problems to bring the total up to 502, consecutively numbered.

Although adverse criticism of details seems usually to give them unjustified emphasis in brief reviews, one detail here deserves such comment. The colored plate, Fig. 28a, for testing color-blindness, may be misleading. After a perfect test of a student for red-green color-blindness with the Ishihara test plates, the reviewer showed him this figure, which he read the same as a person with normal eyes! Everyone who knows the author will see in the combination of "onion" and "color" another example of his cleverly facile approach to the serious details of his teaching, but the printer's use of inks or paper seems to have played him false.

A point in which the book appeals strongly to the reviewer is that it is so distinctly what its title embraces, departing only in a brief chapter on eugenics and in interpolated comments on the evolutionary significance of some of the facts of heredity. With its clear typography, picking out important terms in bold-face, and its simple and intelligible presentation of materials, the new edition should retain the place so deservedly gained by the first as a leader in this field.—A. W. L.