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Comments on Some Problems of Taxonomy of *Oncomelania*

ZAI-BIN KANG

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It is well-known that *Oncomelania* snails are the intermediate host of *Schistosoma japonicum*, which is Asian pandemic. The geographical distribution of schistosomiasis cases entirely corresponds to that of *Oncomelania* snails. According to surveys made in various endemic foci, wherever cases of schistosomiasis were found *Oncomelania* snails were invariably present. But the taxonomy of those snails has been in a chaotic state for a long time. In this paper, the writer dwells on the following seven points. It is hoped that the present work will serve as a reference to further study on these snails.

1. A confused history of oncomelania taxonomy: It has been 103 years since the identification of *Oncomelania hupensis* by Gredler in 1881, and in the literature there were 7 generic names (*Oncomelania*, *Melania*, *Hemibia*, *Prososthenia*, *Blanfordia*, *Katayama* and *Schistosomophora*) and 31 new species (including subspecies). There is no doubt that many of them were synonyms; nevertheless, the possiblility still exists that new species may remain undiscovered. During the past 103 years, there have been three eminent oncomelanian taxonomists, namely, Annandale (1924), Bartsch (1925, 1936a, 1936b, 1939, 1946), and Abbott (1948). Annandale was a pioneer in the thorough revision of oncomelanian taxonomy, combining the Chinese (including Taiwan) and the Japanese taxa into one genus (*Oncomelania*), two groups and five species in all; and laid a sound foundation for the taxonomy of this snail. Bartsch, in dividing the oriental oncomelanian into three genera, eighteen species and two subspecies on the basis of such structures as shell, operculum, radula, etc., pushed the history of oncomelanian taxonomy into a period of enormous splitting. Later, Abbott recombined all oriental oncomelanians (Continental parts as well as Taiwan Province of China, Japan and Philippines) into one genus, 4 species and one subspecies, and thus brought about a period of enormous merging. The result of all these revisions was that some investigators began to be skeptical about the reliability of the basis of oncomelanian taxonomy; some of them even went so far as to negate entirely the taxonomical basis heretofore adopted, yet they did not offer a solution. The taxonomy of *Oncomelania* has been subjected to frequent redivision and recombination resulting in confusion.

2. Oncomelanian taxonomy requires indepth investigation: While there was no compatriot specializing in the classification of *Oncomelania*, a considerable amount of work has been done in China on the embryological development, morphology, anatomy and especially on the ecology and eradication of *Oncomelania*; and in the meantime many views on the taxonomy of *Oncomelania* have been proposed. The opinions of our scholars are quite divergent, but one point in common is that they are aware of possible defects and errors present in the work on oncomelanian taxonomy done abroad. The problem of oncomelanian taxonomy is still open, and awaits further investigation.

3. Controversy of mono-species versus multi-species: Despite the much diversified op-

Department of Parasitology, Hubei Medical College, Wuchang, China.

inions both at home and abroad on the taxonomy of *Oncomelania*, by and large they can be grouped into one of two schools. One school maintains that *Oncomelania* of the world consists of more than one species, whereas the other school suggests that *Oncomelania* consists of one genus and one single species only. The argument for the former school is that *Oncomelania* of the world has conspicuous morphological distinctions; they are also different with respect to geographic distribution, ecology, physiology, ontogeny, immunology and infectivity; therefore more than one species is present. Most of the oncomelanian research workers in this country and abroad adhere to this view (Heude, 1890; Annandale, 1924; Bartsch, 1925, 1936 a, 1936 b, 1939, 1946; Germain et Neveu-Lemaire, 1926; Baylis, 1931; Bequaert, 1928, 1934; Abbott, 1948; Yasuraok, 1969, 1970; Sun, 1964), and the writer also shares their opinion (Kang *et al.*, 1958; Kang, 1981). Concerning the oncomelanian taxonomy we will deal with in another article in detail. We consider that *Oncomelania hupensis*, *O. formosana*, *O. nosophora*, *O. quadrasi*, *O. chiui*, *O. minima*, *O. tangi*, and *O. robertsoni* are all distinct species rather than the same species.

The idea of only one genus and one species is held by Kuo and Mao (1957) who proposed that the specific term *Oncomelania hupensis* Gredler should be used for all *Oncomelania* snails involved in the transmission of schistosomiasis japonica in China. But later Mao *et al.* (1965) also said: "the views of our scholars are still divergent on the taxonomy of the genus *Oncomelania*, in line with the materials now available it could not come to a conclusion, and waits for researches."

Burch (1960 b, 1964, 1966, 1967) found that the four species (*O. hupensis*, *O. formosana*, *O. quadrasi* and *O. nosophora*) all have the same number of chromosomes: n=17, 2n=34. This cytological finding, coupled with the readiness of hybridization as well as the hybrids' capability of producing fertile offspring, led Burch to refer these four species to the same species. But whether this idea is correct or not remains to be discussed.

In recent more than ten years Davis (1967, 1968, 1969 a, 1969 b, 1971, 1973) has studied the oncomelaniid snails of Taiwan, Japan, Philippines and Indonesia. His work is very careful and his papers are well worth reading, but his idea of *Oncomelania* taxonomy is not necessarily correct. His idea fundamentally but not entirely agree with Burch's (1966, 1967). Davis recognizes only one genus with two species and six subspecies. These taxa are *Oncomelania minima* from Japan and the subspecies of *Oncomelania hupensis*, i.e., *O. h. hupensis* from mainland China; *O. h. chiui* and *O. h. formosana* from Taiwan; *O. h. nosophora* from Japan; *O. h. quadrasi* from the Philippines; *O. h. lindoensis* from Sulawesi in Indonesia. It is quite clear that Davis incorporated all the Chinese oncomelaniid snails into a subspecies *Oncotmelania hupensis hupensis*. We considered it is very incorrect. As is known to all, mainland China is the most important distributing centre of *Oncomelania*, where the vector snail of *Schistosoma japonicum* is widespred in 12 provinces and 347 counties. Its natural conditions are very complex, and species may be numerous. Regrettably, Davis has not studied the Chinese oncomelaniid snails. Thus his work of *Oncomelania* taxonomy should not be considered complete.

Liu, Y. Y. (1974) first considered that all the Chinese oncomelaniid snails are probably of only one species (*Oncomelania hupensis*) with a number of subspecies, but afterwards Liu *et al.* (1981) said all the oncomelaniid snails distributed throughout the world should be regarded as a single species, and classified it into 10 subspecies. These subspecies all were originally distinct species. They reduced these species to subspecies and changed their scientific names from binomial nomenclature into trinomial nomenclature. We considered their justification for doing this is not entirely warranted. This change could only create taxonomic confusion.

4. The criterion of chromosome number is not yet up to the level of species identi-

fication: Burch's view may seem justified at first glance, but may not be correct. In order to elucidate the problem, a consideration on the usefulness of chromosome number for taxonomical work seems necessary. According to the literature available to us, chromosome number is of limited significance in taxonomical work. It cannot serve as the sole criterion for the classification of molluscan species. Likewise, it cannot serve as the sole criterion of oncomelanian taxonomy. Early in 1960, Burch himself pointed out that the monocentric and elongate features of chromosomes are the same with aquatic pulmonate snails as with terrestrial ones, and cannot be used to distinguish the two Order (*Basommatophora* and *Stylommatophora*). Eight species belonging to five families of *Basommatophora* have no pronounced difference in the configuration of chromosomes. As to the number of chromosomes, the haploid number are all 18 except one species (n=17); thus, he admitted that chromosome number by itself has very limited value.

Patterson (1967), on the basis of published literature, tabulated the chromosome numbers of streptoneuran snails, most of the species having the same number of chromosomes. If species with the same chromosome number should be reckoned as of the same species, then the numerous species in *Streptoneura* would be "merged" into one and the same species.

We find that Burch's view (1966, 1967) on the taxonomical significane of chromosome number with reference to the intermediate host of human schistosomiasis have been inconsistent and contradictory. He considered the four species of *Oncomelania* to be the same species on the grounds that they all have 17 pairs of chromosomes. But, in his study on 23 species of *Bulinus*, the intermediate host of *Schistosoma haematobium*, 15 species have the haploid number of 18. His observation on 5 species and 2 subspecies of *Biomphalaria*, the intermediate host of *S. mansoni*, disclosed that they all have 18 pairs of chromosomes. If species with the same chromosome numbers should be regarded as belonging to the same species, then all the species of the genus *Bulinus* and the genus *Biomphalaria* should be merged into one species. Yet Burch did not say that they are of the same species; on the contrary he admitted that chromosome numbers, as a general chracteristic, could not facilitate the taxonomy of these snails.

Recently I received a letter from Professor Tan Jia-zhen, the Chinese geneticist, in which he pointed out: "(1) The number of chromosomes is not a definite indicator of species because different species may have the same number of chromosomes. For example *Triticum dicoccum* and *Triticum dicoccoides* are different species, but their morphology and number of chromosomes are the same. (2) The individuals of the species may have different number and morphology of chromosomes such as the individuals of *Catantops brachycerus* Will. have different chromosome morphology. Such instances are too numerous to mention." Therefore, based on the data available, chromosome number in snails cannot serve as the basis of species identification. The identical chromosome number in the four species of *Oncomelania* can only indicate that they are of the same genus, but not the same species.

5. The significance of hybridization test in oncomelanian taxonomy: The value of the hybridization test to oncomelanian taxonomy also needs discussion. Wagner *et al.* (1957, 1959), Komiya *et al.* (1958, 1959, 1960) and Davis *et al.* (1965) succeeded in the hybridization of oncomelanian species and obtained fertile offspring. On this ground, Komiya *et al.* raised the question of whether *O. nosophora* and *O. hupensis* are really two distinct species. Wagner *et al.*, on the other hand, pointed out that if experimental hybridization can serve as the criterion of species identification, then the four oncomelanian taxa should be regarded as four subspecies, yet for the convenience of clinicians and public health workers, they should retain their original scientific names so as to avoid confusion.

Sun Zhen-zhong (1964), having analysed

Wagner's results of hybridization, pointed out: "The external morphological features of some of the offspring resembled the paternal parent, some resembled the maternal parent, yet the paternal and maternal parents were of two taxa. Morphological features of both taxa can pass to the F_1 hybrids through heredity. In other words, whereas either taxon has inheritable characteristics of its own, both features can pass to the F_1 generation; since each taxon possesses inheritable capacity, it fulfills the characteristics of a species. Therefore, the four taxa used in the hybridization test were not of the same species. Besides, the copulation rate, fecundity and duration of breeding season are higher and more condensed in the crossings within the same taxon than in the crossings between different taxa, and this is an evidence of the four taxa used in hybridization tests being not of same species."

Hsu and Hsu (1960) believed that the four species mentioned above, of *Oncomelania* became distinct not only physiological but also morphologically, therefore, they are four distinct geographical species rather than the same species. But because isolation is not complete, interspecies breedings are still possible.

Davis *et al.* (1965) crossed a female *O. quadrasi* with a male *O. formosana* and obtained one single male hybrid, which was abnormal in many aspects. Externally, the antennae had many branches, and there were 7 eye masses. Internally, the salivary glands were malformed, the antennal nerve became greatly thickened, the sex glands showed atrophy. This abnormal male hybrid was reared together with several normal female hybrids in the laboratory for 21 months, but no offspring was produced although copulation took place often. This fact indicates that *O. quadrasi* and *O. formosana* are not of the same species. Yet Davis *et al.* held that thousands of hybrids were normal, the vitality of F_1 and F_2 was not weakened; indicating that these *Oncomelania* were of subspecific or conspecific nature.

It is well known that different species of *Oncomelania* possesses varying degree of susceptibility to infection with geographic strains of *Schistosoma japonicum* (Hunter *et al.*, 1952; DeWitt, 1954: Pesigan *et al.*, 1958; Vogel, 1948; Yuan, 1958; Hsu *et al.*, 1960; Moose *et al.*, 1963 b; Chiu, 1967). In recent years the susceptibility of *Oncomelania* hybrid snails to schistosome infection has been reported. According to the report of Moose and Williams (1963 a), the Japanese strain of *S. japonicum* did not develop in the hybrid of *O. nosophora* and *O. formosana*. Chi *et al.* (1971) pointed out that the infection rate in hybrid snails (7.1%) is lower than that in the geographically natural snail hosts (22.4%). Chiu *et al.* (1981) observed that *Oncomelania* recombinants or hybrids were found to be susceptible to the original strain of *S. japonicum*, however, the susceptibility declined markedly by each generation. This difference in susceptibility also indicated that these taxa of *Oncomelania* were not of the same species, though hybridization between them did occur.

Besides, van der Schalie, Getz and Dazo (1962) reported the success of crossing between these species (*Oncomelania formosana*, *O. quadrasi*) and the American *Pomatiopsis lapidaris*. In his book ≪Historical Laws of Biological Development≫ Chen Shi-xiang (1978 b) wrote: "At Gaogang Commune of Fenyi County in Jiangxi Province, cattle was put out to pasture together with water buffalo over a long period of time. Eventually the hybridization between them has met with success and the hybrid produced has been propagating many generation." These facts demonstrate even more clearly that interspecific hybridization, intraspecific hybridization, as well as distant species hybridization, is possible. Therefore, the four species mentioned above, of *Oncomelania* (*O. hupensis*, *O. formosana*, *O. nosophora*, *O. quadrasi*) are not of the same species, though they could hybridize artificially.

Taxonomists of the past deemed infertile hybridization as the classical criterion of species: taxa that produce fertile hybrids are considered to be the same species, those pro-

ducing infertile hybrids are considered as different species. In general, this idea is still in vogue as a criterion of species at present, but, just as Chen Shi-xiang (1978 a) indicated, the application of this criterion has certain limits, and the demarcation line of infertile hybridization is also not absolute. Under given condition, different species and even distant species can also hybridize and produce a generation of fertile hybrids.

6. Morphological characteristics are important in taxonomy: All classification of animals used morphological structures as the chief characteristic for the convenience not only of recognizing the species, but also of practical application. The morphological characteristics of each animal species have been formed through long stages of evolution in a given environment and thus imply much importance. Although morphological variation may occur under the influence of environmental factors, in most cases morphological characteristics of animals, once formed, can pass on generation after generation. Generally speaking, morphological difference reflects indirectly the genetical difference, thus morphological characteristics may be taken as the basis of classification. Chen Shi-xiang (1964) wrote: "Morphological characteristics as a basis of classification reflect the unification between continuity and interruption through the unification of the morphological conformity and specificity. That is to say, phylogenetical homogeneity and continuity are reflected by morphological conformity, whilst divergence and interruptions are reflected by morphological specificity. Therefore, morphological characteristics have the significance of "marking in a twofold sense: as a mark of classification and as a mark of phylogeny. These two markings must be unified." Heude (1890), Annandale (1924), Bartsch (1925, 1936 a, 1936 b, 1939, 1946) and Abbott (1948) all based their classification on the morphology of *Oncomelania*. Despite of shortcoming and errors in their taxonomical studies, we should in no way negate the importance of morphological attributes to taxonomical study.

7. Integrative characteristics should be adopted in subsequent taxonomical study of *Oncomelania*: The 103-year history of taxonomical study on *Oncomelania* demonstrates that none of the single characteristics is satisfactory. Morphological characteristics are more convenient and practical but sometimes it is not sufficient to rely on morphological features alone, especially in cases of closely allied species, for which an identification based solely on morphology would be extremely difficult. As to chromosome number, the literature has documented that most of the snails have the same number; thus chromosome number does not afford sufficient criteria for species identification. Hybridization tests in general are fairly important for taxonomical study, but their application has met with certain limitations; there are cases of interspecific hybrids formed as a result of incomplete isolation, thus making a discrimination of species difficult. From what appears in the current literature, hybridization tests also cannot be used as the sole criterion of oncomelanian taxonomy. What should be taken as the basis of classification then? We suggest the adoptation of integrative characteristics. The more data of characteristics available, the more scientific the taxonomic study will be. Specifically, we mean to take morphological characteristics as the basis, which, in conjunction with ecological, physiological, biochemical, ontogenetic, cytogenetical and zoogeographical characteristics, allow integrative and comparative study, so as to elucidate the species composition of *Oncomelania* and its phylogenetic relationship. This would not only be of theoretical interest, but also important in practice, for prophylaxis and therapy of schistosomiasis caused by *Schistosoma japonicum*.

Summary

The present paper deals with seven taxonomic problems in the molluscan genus *Oncomelania*. During the 103-year history it may be found that the taxonomy of *Oncomelania* has been subjected to redivision and recombination once and again and has fallen

into utter confusion. But the problem of *Oncomelania* taxonomy has not yet been resolved and still awaits for deep-going researches. The value of the chromosome number, hybridiz ation test and morphological characteristics on the taxonomy has been discussed. A temporal conclusion may be made that the chromosome number can not be used as a taxonomy mark on the level of species yet, nor is hybridization test as the sole criterion of oncomelanian taxonomy. So the morphological characteristics are still an important and valuable parameter in taxonomy. The author does not agree with Liu *et al.* (1981) that there is only one genus and one species of *Oncomelania* all over the world. Many evidences are presented to favor the view that it consists of more than one species. A suggestion has been made that the integrative characteristics should be adopted in subsequent taxonomical study of *Oncomelania*.

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Oncomelania 属の分類学上の諸問題について

KANG ZAI-BIN
（中国，湖北医科大学寄生虫学教室）

Oncomelania 属貝の分類学上の問題につき，7つの観点から考察した．この貝の発見以来103年を経た現在でも，その分類学上の問題は解決をみていない．ここでは，この貝の分類学上における染色体数，交雑試験，形態学的特徴の価値について考察した．結論的に言えば，染色体数も交雑試験も，*Oncomelania* 属の種の分類には適さず，形態学的特徴が依然重要で価値のあるパラメーターであるということである．筆者は，*Oncomelania* 属は1属1種であると意見には賛成できない．1種以上からなることを示す多くの証拠が得られているからである．今後の研究では，総合的な特徴を重視すべきである．