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RECENT ADVANCES IN THE STUDY OF CHINESE GOMPHIDAE (ANISOPTERA)

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So far 145 spp. and sspp., referable to 35 genera (incl. *Melligomphus* gen.n., generotype : *Onychogomphus ardens* Needham, 1930) and to 4 subfamilies, are known from China. The immature stages of 34 spp. were recorded from the Chinese territory.

GENERAL REVIEW OF THE CHINESE GOMPHID FAUNA

In 1930, NEEDHAM published a book called "A manual of the dragonflies of China" which laid down the basis for the study of Chinese dragonflies. Several additions and corrections were made by him in the following years (1931, 32, 41, 48). In his publications, there were 58 species of gomphid dragonflies in 13 genera recorded from China. CHAO in 1953-55 raised the number to 101 in 26 genera, including 2 new genera and 25 new species. This was the first attempt to group Chinese gomphid dragonflies into 3 subfamilies, Gomphinae, Hageniinae and Ictinogomphinae, in which previous authors' Epigomphinae were merged for the first time with Gomphinae into a single subfamily. In 1984, CHAO erected a new subfamily, Onychogomphinae, to include several genera taken out from the Gomphinae. This system of classification in 4 subfamilies is the one adopted in the present study. During the last 40 years, many important contributions have been made by ASAHINA, LIEFTINCK, CHAO and others to bring the knowledge of Chinese gomphid dragonflies up to date, resulting in a rapid increase in the number of new taxa in the family.

THE *GOMPHUS*-COMPLEX

In earlier publications, both *Gomphus* and *Onychogomphus* were two large heterogeneous genera. The complexity of these two genera has gradually been understood through careful studies by modern specialists.

With regard to the genus *Gomphus* Leach, NEEDHAM (1930) recorded 21 Chinese species. Later he tried to split it. In 1941 he erected 3 new genera, *Gastrogomphus*, *Eogomphus* and *Xenogomphus*, the first two for the reception of *abdominalis* McLachlan and *neglectus* Needham respectively and the last one for the reception of *agricola* Ris and its allies. *Xenogomphus* was later considered as a synonym of *Trigomphus* Bartenef, 1912, by CHAO (1954) and following authors.

In 1935, MAY stated a new genus *Sinogomphus* for his new species *nigrofasciatus* as the generotype. This genus was suppressed as a synonym of *Gomphus* by LIEFTINCK (1939), who described 5 new species very closely related to *nigrofasciatus* May, 1935. He considered : "These species can be referred to the genus *Gomphus* with tolerable satisfaction", he argued that "they form a natural group within that genus and the features of the venation, uniting them, are neatly backed by colour peculiarities and the hape of the male genitalia and anal appendages". However, CHAO (1954) re-established the genus *Sinogomphus*, based on a careful study of the various parts of the male genitalia and anal appendages as well as the female subgenital plate and the 9th abdominal sternite.

NEEDHAM (1948) in his study of North American species of the genus *Gomphus* had noticed differences between Chinese and North American representatives of the *Gomphus*-complex. He stated : "Some of the other Chinese species do not fit very well into the categories of genera and subgenera herein discussed". He (1948) correctly assigned *clathratus* to *Stylurus* and transferred his earlier species *Gomphus gideon* Needham, 1941, to the same genus. However, his assignment of *Gomphus septimus* Needham, 1930, to *Arigomphus*, was not correct. Both the American genera *Gomphus* and *Agrigomphus* have not been found in China. The significance of NEEDHAM's introducing the name *Stylurus* into literature concerning the Chinese gomphid fauna was neglected by CHAO (1953), who did not differentiate *Stylurus* from *Gomphus* in his earlier publication.

In 1985, ASAHINA proposed a new genus *Asiagomphus* in order to include many species from China, Japan and neighbouring countries previously placed in the genus *Gomphus*. This was a great step towards the solution of the complexity of the heterogeneous genus *Gomphus*. However, a few modifications should be made. CHAO in his recent study has revealed that *Asiagomphus* can easily be recognized by the dorsal stripe confluent with the collar stripe to form an inverted 7-shaped mark on each side of the synthoracic crest. Three species, *szechuanicus* (synonymyzed with *amicus*, CHAO, 1986), *gaudens*

and *takashii*, which were placed by ASAHINA (1985) in *Asiagomphus* do not present this character. In these species, the dorsal stripes are not confluent with the collar stripe. This is a character of the genus *Stylurus*, to which they should belong. The two genera are different in colorations as well as in the shape of the posterior hamuli and other characters.

CARLE (1986) erected a new subgenus *Anatogomphus* with *Gomphus personatus* Sélys, as its type species. This species was included in *Asiagomphus* by ASAHINA (1985). Hence, *Anatogomphurus* Carle, 1986, is synonymyzed with *Asiagomphus* Asahina, 1985.

It seems appropriate here to give some remarks about *Stylurus* in China. Recent studies have revealed that the genus *Stylurus* can easily be recognized by the shape of the posterior hamuli as well as by the colour marking on the frontal surface of the synthorax, as mentioned above. The posterior hamuli are long, narrow and always perpendicular or tangential to the longitudinal axis of the body. It is now known that the genus *Stylurus* contains 14 species in China. A similar number of species represents the genus in Eastern Asia and North America.

In 1984, CHAO established *Shaogomphus* for the sole new species *lieftincki*. CARLE (1986) questioned if *lieftincki* was a synonym of *Gomphus postocularis* Sélys, *G. chancae* Bartenef, or *G. schmidti* Asahina. However, it is much larger than these. In *lieftincki*, the hind wings are 38 mm long, while in the others, they range between 30 and 33 mm. Another difference is that *lieftincki* lacks a dorso-subapical spine in the male inferior anal appendages. ASAHINA (1985) retained *postocularis* Sélys, 1850, *postocularis epophthalmus* Sélys, 1872 and *schmidti* Asahina, 1956 (= *chancae* Bartenef, 1956) in the genus *Gomphus* (s.str.). They are hereby transferred to *Shaogomphus*, a genus characterized by a thick body and a short abdomen, with the apical half of the superior anal appendages strongly curved ventrad almost in a right angle, and a pair of large round tubercules on the upper part of the posterior surface of the head capsule behind the eyes.

A careful study of the type species *vulgatissimus* Linnaeus, 1758, has revealed several important characters, such as the anal triangle of the male hind wings with more than 4 cells arranged in two vertical rows and the anterior hamuli bifurcated. None of the Chinese species previously placed in *Gomphus* show such characters. It is very probable that there is no true *Gomphus* in China.

To summarize the points mentioned above, we can see that there was a great change in the classification of the *Gomphus*-complex in China during the second half of the century. Generic changes of the Chinese *Gomphus*-complex are presented below :

Needham (1930-32)	Needham (1941)	Chao (1953-55)	Present status
Gomphus Leach, 1815	*Gomphus* Leach, 1815	*Gomphus* Leach, 1815	(*Gomphus* Leach — none)
	Eogomphus Needham, 1941	*Eogomphus* Needham, 1941	*Eogomphus* Needham, 1941
	Gastrogomphus Needham, 1941	*Gastrogomphus* Needham, 1941	*Gastrogomphus* Needham, 1941
		Trigomphus Bartenef, 1912	*Trigomphus* Bartenef, 1912
		Burmagomphus Williamson, 1907	*Burmagomphus* Williamson, 1907
		Sinogomphus May, 1935	*Sinogomphus* May, 1935
		Fukienogomphus Chao, 1954	*Fukienogomphus* Chao, 1954
	Needham (1948)		*Asiagomphus* Asahina, 1985
	Stylurus Needham, 1897		*Stylurus* Needham, 1897
			Shaogomphus Chao, 1984

THE CHINESE ONYCHOGOMPHINAE

The subfamily Onychogomphinae was established by Chao in 1984. This practice was followed by Davies & Tobin (1985) with caution. They said : "its popularity has yet to be tested". Carle (1986) divided Onychogomphinae into two tribes, namely Crenigomphini and Onychogomphini. The genus *Paragomphus* which occurs in China goes in the former tribe, while all the remaining Chinese genera go in Onychogomphini.

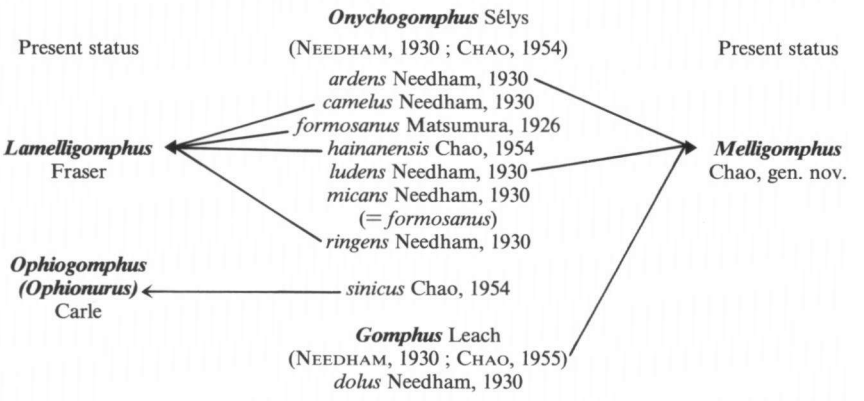
Onychogomphus Sélys, 1857, is a very large and heterogeneous old world genus under which Davies & Tobin (1985) list 72 species, including *Lamelligomphus* Fraser, 1922, *Nepogomphus* Fraser, 1934 and *Paradigma* Bucheck, 1876, as synonyms. Previously, Laidlaw (1922) divided the Asiatic species of this genus into 4 sections. Three of them were later designated as genera, *Lamelligomphus* Fraser, 1922, *Nepogomphus* Fraser, 1934 and *Paragomphus* Cowley, 1934. The systematic status of the fourth section remains unsettled until recently when Chao (1987) established a new genus *Orientogomphus* for the reception of the exotic species of this section comprising *aemulus* Lieftinck, 1937 (Sumatra), *circularis* Sélys, 1894 (= *naninus* Förster, Chao, 1987) (Burma, Vietnam) and *earnshawi* Fraser, 1924 (Burma), with his new species *armatus* as generotype.

Carle (1986) divided the genus *Onychogomphus* into 2 subgenera, the nominate subgenus *Onychogomphus* and the new subgenus *Nychogomphus*. The latter has *Onychogomphus geometricus* Sélys as the type species. Carle said : "As presently defined, the subgenus *Onychogomphus* does not occur in China or India".

CARLE (1986) defined the nominate subgenus *Onychogomphus* as having "prepuce spinelike and directed anterodorsally". A close examination of the penis of the type species *Onychogomphus forcipatus* (Linnaeus, 1758), has revealed that there is a prepuce produced dorsally from the middle segment and a pair of spinelike processes directed anterodorsally at the base of the distal segment. The prepuce is mostly covered by the spinelike process when the penis is seen from lateral view. This feature was neglected by FRASER but the spinelike process is well shown in figures of the lateral view of the penis of the type species and its congener *O. uncatus* (Charpentier, 1840), FRASER (1940, pl. 2). None of the Chinese species possess a similarly structured penis. It is very likely that the nominate subgenus *Onychogomphus* does not occur in China.

CARLE (1986) also referred to "the *Onychogomphus* of CHAO (1954) being *Lamelligomphus*". This is rather a complicated problem. Actually, the 8 species that CHAO (1954) placed in *Onychogomphus* should belong to 3 different genera. The elongate hooklike apex of the posterior hamuli in *Onychogomphus sinicus* Chao, 1954, indicates that it should be transferred to *Ophiogomphus (Ophionurus)* Carle, 1986. The overlapping of the apically upcurved inferior anal appendage over the outer surface of the down-hooked superior anal appendage which forms a loop in profile in *O. camelus* Martin, 1904, *O. formosanus* Matsumura, 1926 (= *micans* Needham, 1930), *O. hainanensis* Chao, 1954, *O. ringens* Needham, 1930, as well as some later additions such as *Lamelligomphus choui* Chao & Liu, 1989 and *L. motuoensis* Chao, 1983, indicates that they belong to *Lamelligomphus* Fraser. The remaining 2 species, *O. ardens* Needham, 1930 and *O. ludens* Needham, 1930, have a prepuce on the middle segment of the penis and the anal appendages are elongate but not overlapping; so they should be placed neither in *Lamelligomphus* nor in *Nychogomphus*. Hence a new genus *Melligomphus* is erected for them, with *ardens* as the type species. CHAO (1981) described a new species *Onychogomphus flavicaudus* and CHOU (1987) recorded *O. dingavani* Fraser, 1924 (Burma) from Yunnan province, Southern China. The former is now transferred to *Nychogomphus* Carle, 1986, while the latter is a member of *Phaenandrogomphus* Lieftinck, 1946, which is a new combination.

The following chart summarizes our present knowledge of the *Onychogomphus*-complex in China.



THE CHINESE HAGENIINAE

In the present study, the author is in agreement with consigning all the Asiatic species to the genus *Sieboldius* Sélys, 1854 and the single nearctic species to the genus *Hagenius* Sélys, 1854. The genus *Sieboldius* is divided into 2 instead of 3 subgenera, as proposed by Carle (1986). This is contrary to the practice the author had adopted in his earlier paper (Chao, 1955) in which he treated *Sieboldius* as subgenus of *Hagenius*.

ZOOGEOGRAPHICAL DISTRIBUTION

The remarks the author will present now on the subject of zoogeographical distribution of Chinese Gomphidae are tentative and must be viewed in conjunction with two important considerations : — **1** — that the gomphid fauna in many provinces of China other than Fujian has not been thoroughly explored, and — **2** — that our knowledge about the gomphid fauna of our neighbouring countries in South Asia is limited. Thus, while it is possible to give some idea of the range of distribution, it is possible that our observations on the abundance of species in any particular region will require modification when additional data become available.

Based on the material which was obtained up to now, the distribution of Chinese gomphid genera is presented in Table I.

From Table I, it can be seen that, with the exception of *Ophiogomphus* (s.str.), all the genera occur in the Indo-Chinese Subregion of the Oriental Region. It seems that the Indo-Chinese Subregion might be the head-quarter of distribution from where gomphids spread radially to various parts of the Old World. As compared with the abundance of the gomphid fauna in North America, Needham (1948) had mentioned : "There is a secondary center of abundance in East Asia". It seems that the gomphid fauna radiates from this

Table I

Zoogeographical distribution of Chinese gomphid dragonflies by genera
(E = Eastern North America)

	Afrotropical	Western Palaearctic	Oriental				Austral-asian		Eastern Palaearctic	Nearctic
			Ceylonese	Indian	Indo-Chinese	Indo-Malayan	Wallacean	Australo-Tasmanian		
GOMPHINAE										
Asiagomphus					+				+	
Stylurus		+		+	+				+	+
Gastrogomphus					+					
Shaogomphus					+				+	
Labrogomphus					+					
Macrogomphus			+	+	+	+				
Burmagomphus					+	+				
Heliogomphus			+	+	+	+				
Anisogomphus			+	+	+					
Merogomphus					+					
Fukienogomphus					+					
Trigomphus					+				+	
Sinogomphus					+				+	
Stylogomphus					+				+	+E
Davidius				+	+	+			+	
Leptogomphus					+	+				
Eogomphus					+					
ONYCHOGOMPHINAE										
Nychogomphus				+	+					
Paragomphus	+	+	+	+	+	+	+			
Nihonogomphus					+				+	
Orientogomphus					+	+				
Amphigomphus					+					
Megalogomphus			+	+	+	+				
Lamelligomphus				+	+				+	
Melligomphus gen. nov.					+					
Nepogomphus				+	+					
Ophiogomphus (s.str.)		+		+					+	+
O. (Ophionurus)					+					+E
Phaenandrogomphus					+	+				
HAGENIINAE										
Sieboldius (s.str.)					+				+	
S. (Pseudohagenius)					+					
LINDENIINAE										
Ictinogomphus				+	+	+	+	+		
Sinictinogomphus					+				+	
Gomphidia	+			+	+	+				

centre along three routes. — **1** — Those of the first route spread along Eastern Asia northwards and reach Siberia where they part in two directions : the Eastern branch having crossed the Bering Strait in ancient geologic times to reach North America, and the Western branch reaching Europe. There is a fairly large percentage consisting of 3 genera, *Stylurus*, *Stylogomphus* and *Ophiogomphus* that reaches North America. On the other hand, there is only one species in each of the two genera *Stylurus* and *Ophiogomphus* (s.str.) that has an Eurasian distribution. — **2** — Those of the second route, *Paragomphus* and *Gomphidia*, are spread in two directions. The former spreads westwards to Africa with a minor branch reaching Europe, the other spreads from the Indo-Chinese Subregion southwards to reach the Wallacean Subregion of the Australian Region. — **3** — Those of the third route with *Ictinogomphus* as representative extend southwards to reach the Australian Region.

Another feature of interest is the great abundance of genera and species in the Indo-Chinese Subregion + Eastern Palaearctic Region. In fact, ASAHINA (1960) pointed out the similarity of the Japanese gomphid fauna with that of the Himalayan Region ; 3500 miles separate them. The distribution of 18.8% of genera and 15.6% of species of the japanese dragonflies is of this nature. The present study has revealed that 9 out of 33 genera constituting 27.3% of the total Chinese gomphid fauna have a similar pattern of distribution.

A brief review of the gomphid fauna of the two large islands Taiwan and Hainan is given below. There are 16 and 11 genera in Taiwan and Hainan respectively. All of them occur also on the neighbouring mainland of the other side of the strait. Out of a total of 21 species that occur in Taiwan, 14 also occur in Fujian, constituting 66.7% of the total gomphid fauna in Taiwan. The remaining 7 endemic species are very close congeners of Fujian species. Similarly, out of the 14 Hainan species, half of them are endemic. These facts indicate that the gomphid fauna of Taiwan, Hainan and the neighbouring mainland provinces Fujian and Guangdong are very similar to each other. This can be explained by the fact that these two big islands were connected with the mainland by dry land early in the glacial period, when the sea level was much lower than now.

Finally, one point worth mentioning is that although China has a rich gomphid fauna, our knowledge of the taxonomy and zoogeographical distribution of this fauna is still fragmentary. Gomphids in Fujian are fairly well explored. There are 60 species in this area of 126,000 square kilometers. But the gomphid fauna in the vast area of China, especially in the Southern provinces bordering the countries in South-Eastern Asia, has not been thoroughly explored. An optimistic estimation of the total gomphid fauna in China might reach close to 200 species. There is still a lot of work to be done.

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