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Contribution to the knowledge of seed chalcids, *Megastigmus* spp. (Hymenoptera: Torymidae), in China, with the description of three new species

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A survey of *Megastigmus* seed chalcids was carried out on 16 conifer and 2 *Rosa* species from China in 1993-94. X-raying showed that *Megastigmus* larvae infested seeds in 14 of the surveyed tree species. In some tree species, chalcid larvae remained in prolonged diapause, thus preventing complete identification of the insect species. Three *Megastigmus* species new to science were described from seeds of *Cupressus* spp., *Juniperus pingii,* and *Picea likiangensis* collected in Yunnan Province. In addition, a *Megastigmus* species only recorded in Japan was observed on *Picea koraiensis* in Heilongjiang Province. At present, a total of 9 species of *Megastigmus* seed chalcids are known in China.

Keywords: seed chalcid, damage, *Megastigmus,* Conifer, *Rosa,* China.

INTRODUCTION

The development of reforestation programs implies a renewed attention to insects damaging cones and seeds (TURGEON *et al.,* 1994). Among them, phytophagous chalcids of the genus *Megastigmus* DALMAN (Chalcidoidea: Torymidae) proved to be serious tree seed pests all over the world (LESSMAN, 1962; STADNITSKII *et al.,* 1978; HEDLIN *et al.*, 1980; ROQUES, 1983). At the present time, a total of 45 *Megastigmus* species have thus been recorded to attack conifer seeds from families Pinaceae, Cupressaceae and Taxodiaceae (YATES, 1986; TURGEON *et al.,* 1994), a few additional species infesting seeds of broadleaved trees, especially those of Rosaceae (MILLIRON, 1949), and even figs (BOUČEK, 1988).

Despite the large number of potential conifer hosts, only a few species of *Megastigmus* have been recorded to infest seeds in China, i.e. *M. cryptomeriae* YANO et KOYAMA on *Cryptomeria* spp. (HE, 1984; ZHANG, 1987; XU *et al.,* 1989), *M. pictus* FÖRSTER on *Larix gmelini* (RUPR.) KUSEN. (ZHANG & ZHOU, 1990), *M. sabinae* XU et HE on *Juniperus* spp. (XU & HE, 1989; WU *et al.*, 1992, 1993), and an unidentified species on *Pseudotsuga gaussenii* FLOUS (ZHOU, 1978). In addition, *M. aculeatus* SWEDERUS has formerly been noticed in *Rosa* seeds (MILLIRON, 1949), whilst *M. sinensis* SHENG was observed to develop in bamboo shoots (SHENG, 1989). Most of the species described in Japan (HUSSEY & KAMIJO, 1958; KAMIJO, 1958, 1962; SAITO & YAMAMOTO, 1985) and India (MATHUR, 1955; SUBBA RAO & HAYAT, 1986) have not been observed in China yet.

Life cycle features of *Megastigmus* spp. tend to facilitate insect introduction and establishment in exotic countries. The larval development occurs entirely within the same seed, with a winter diapause that may extend to several additional years (TURGEON *et al.,* 1994). The development of seed trading at national and international level therefore includes large risks of chalcid introduction with seed lots when sanitary measures are not applied preventively. From this point of view, a precise knowledge of the potential of seed infestation by insects in native areas of trees is required. The primary goal of our work was therefore to perform a survey of *Megastigmus* species developing in seeds of some economically important conifers of China, mainly from Heilongjiang and Yunnan Province.

MATERIAL AND METHODS

A total of 16 conifer and 2 *Rosa* species were surveyed in 1993-1994: *Abies delavayi* FRANCHET (= *A. georgei* ORR.), *Biota (= Platycladus= Thuja) orientalis* (L.) ENDL., *Cupressus duclouxiana* HICKEL., *C. funebris* Endl., *C. torulosa* D.DON, *Juniperus (= Sabina) pingii* (CHENG EX FERRÉ) CHENG et T.W.WANG, *J. sibirica* BURGS., *J. squamata* BUCH., *Larix gmelini, L. olgensis* (HENRY) OST. et SYR. LARS., *L. potaninii* BATALIN var. *macrocarpa* LAW., *L. principis-rupprechtii* PILG., *Picea koraiensis* NAKAI, *P. likiangensis* PRITZEL, *Pinus sylvestris* L. var. *mongolica* LITVIN, *Pseudotsuga sinensis* DODE, *Rosa acicularis* LINDL. and *R. davurica* PALL. In most tree species, we collected random samples of mature cones in May-June 1993 (1992 crop) and in December 1993 (1993 crop). Then, we extracted the entire seed content manually. In addition, the Forestry Bureaux of Daï-ling, Jagedaqi, Xin-lin (Heilongjiang), Wangching (Jilin), Guandi Moutains (Shanxi), and Lijiang (Yunnan) supplied seed lots selected at random from the 1992 and 1993 seed harvests. All the seed lots were radiographed using a Faxitron-43855® apparatus (15 Kv, 3 mA, 3'30" to 4'30" according to seed species) and X-ray sensitive films (Kodak® "Industrex M"). Respective numbers of filled seeds, empty seeds, and seeds infested by insect larvae were counted. Then, insect-infested seeds were placed in individual rearing boxes stored in an outdoor insectary located at INRA, Orléans, France (107 m elevation). Adult emergence was recorded from July 1993 to August 1994. The emergence dates were only indicative because of differences in altitude and climatic conditions between native and rearing sites. When no adult emerged at all because of prolonged diapause, we dissected some infested seeds to assess whether larvae were *Megastigmus* spp. or other seed insects, e.g. seed midges and *Eurytoma* seed chalcids. Collecting net was also used in June 1993 to catch adult chalcids possibly ovipositing on cones.

Adult morphology was finally compared to that of *Megastigmus* species already known to infest congeneric tree species in Eurasia, using both literature data and reference collections. Dr. K. KAMIJO (Hokkaido, Japan) provided us with some Japanese specimens. We also used the reference collection of one of us (A.R.) and that of the French National Museum of National History, Paris, France. The morphological terms used in this work to describe adult chalcids refer to the terminology defined by BOUČEK (1988).

RESULTS AND DISCUSSION

Overall seed damage

Seeds were infested by larvae of *Megastigmus* spp. in 14 of the 18 surveyed tree species (Tab. 1). Because of the limited size of the samples, the absence of seed chalcid did not prove that the tree species was not colonized, except *Pinus sylvestris*

(var. *mongolica*) that never showed any seed chalcid damage throughout Eurasia (STADNITSKII *et al.,* 1978; ROQUES, 1983). The importance of chalcid damage to seeds varied with tree species, site (e.g., in *Larix gmelini*), and year (e.g., in *Picea koraiensis*). Large annual variations in damage have already been shown in *Megastigmus* spp., whose population dynamics appeared to be regulated by the annual change in the size of the host seed crop (ANNILA, 1982; ROQUES, 1983). However, seed damage usually remained inferior to 10% of the seed crop, except in *Picea koraiensis* and *Juniperus pingii*. As *Megastigmus* seed chalcids oviposit only at the end of the process of cone growth (ROQUES, 1983), competitive interactions with cone insects that possibly colonized the cone earlier in the season might have limited chalcid damage. The absence of data regarding cone entomofauna in most of the surveyed tree species prevented any conclusion, but large damage by seed chalcids has essentially been observed in other countries when there are no or few competitors for the seed resource, e.g. in the countries of introduction of Douglas-fir where the specific *M. spermotrophus* is the only cone insect pest (ROQUES, 1983). In most of the surveyed trees, *Megastigmus* larvae largely dominated the seed insect complex, except in *Larix gmelini* where *Eurytoma laricis* YANO (Hymenoptera: Torymidae) was the major seed pest in the Da Xingganling, i.e. at Xin-lin and Jagedaqi. ZHANG *et al.* (1991) had already noticed this dominance of Eurytomids in the area. Unfortunately, a large part of the *Megastigmus* larvae remained in prolonged diapause during our study, and thus hindered species identification in some of the surveyed trees.

Tab. 1. Surveyed tree species, location, seed quality and extent of *Megastigmus*-damage.

Tree species	Cone Crop Year	Location	Province	Total Nb seeds	*Megast.* seeds (%)	Filled seeds (%)	Empty seeds (%)	Infested seeds (%)
Abies delavayi	1992	Lijiang	Yunnan	769	3.9	82.3	13.1	4.6
Biota orientalis	1993	Anning	Yunnan	252	0.0	100	0.0	0.0
Cupressus duclouxiana	1992	Anning	Yunnan	374	6.4	91.8	1.8	6.4
	1993	Anning	Yunnan	644	2.8	44.1	52.8	3.1
Cupressus funebris	1992	Kunming	Yunnan	187	5.3	94.6	0.0	5.4
Cupressus torulosa	1992	Anning	Yunnan	1000	0.3	99.7	0.0	0.3
Juniperus pingii	1993	Lijiang	Yunnan	84	17.8	78.6	3.6	17.8
Juniperus sibirica	1993	Xin-lin	Heilong.	280	0.0	0.0	0.0	100
Juniperus squamata	1993	Anning	Yunnan	1000	0.1	88.9	11.0	0.1
Larix gmelini	1992	Xin-lin	Heilong.	1000	0.9	74.0	22.1	3.9
	1992	Daï-ling	Heilong.	1000	7.0	81.8	10.6	7.6
	1993	Jagedaqi	Heilong.	1000	0.5	17.2	64.4	18.4
Larix olgensis	1993	Wangching	Jilin	1000	7.8	74.3	17.9	7.8
Larix potaninii	1993	Lijiang	Yunnan	136	0.0	91.2	8.8	0.0
Larix principis-ruppr.	1993	Guandi Mts	Shanxi	1000	0.5	96.9	2.6	5.0
Picea koraiensis	1992	Xin-lin	Heilong.	243	1.6	79.8	18.5	1.6
	1992	Hong-lin	Heilong.	461	38.1	45.8	16.1	38.1
Picea likiangensis	1992	Lijiang	Yunnan	1000	6.1	75.3	18.7	6.1
Pinus sylvestris mong.	1993	Jagedaqi	Heilong.	1000	0.0	100	0.0	0.0
Pseudotsuga sinensis	1993	Anning	Yunnan	258	0.4	61.6	38.0	0.4
Rosa acicularis	1992	MoErShan	Heilong.	189	3.7	96.3	0.0	3.7
	1992	Hong-lin	Heilong.	198	0.0	91.9	8.1	0.0
Rosa davurica	1992	Jagedaqi	Heilong.	1019	0.0	92.9	7.1	0.0

Megastigmus species infesting Abies seeds

Larvae of a species, *Megastigmus* sp., were observed in seeds of *A. delavayi* provided by the Lijiang Forestry Bureau (Tab. 1). The seeds originated from the lower slopes of Yulongxueshan (27°01'N, 100°09'E, 3000-3300 m elevation). However, no adult emerged from any of the 30 chalcid-infested seeds. Thus, the chalcid species could not be identified, yet. Three species of *Megastigmus* had already been reported to attack fir seeds in eastern Asia. *M. borriesi* CROSBY was recorded on *A. sacchalinensis* (Fr. SCHMIDT) MAST., *A. sikokiana* NAKAI, and *A. mariesii* MAST., whilst *M. firmae* KAMIJO attacked *A. firma* SIEB. and ZUCC. in Japan (KAMIJO, 1962). STADNITSKII *et al.*, (1978) also reported *M. suspectus* BORRIES in seeds of *A. nephrolepis* MAXIM. in Far Eastern Russia whilst *M. specularis* WALLEY may exist on *Abies sibirica* LEDEB. in the Novosibirsk region of Siberia (RODD in BOUČEK, 1970). Though the identification of the last insect species has to be confirmed, stands of *A. nephrolepis* have to be surveyed in northeastern China for the likely presence of seed chalcids.

Megastigmus spp. infesting Cupressus seeds

A total of 25 adults emerged from insect-infested seeds of *C. duclouxiana* (10 ♂♂, 8♀♀) and *C. torulosa* (3♂♂, 4♀♀) that were collected on 5 December 1993 at Anning Hot Springs, Anning County (24°58'45"N, 102°27'02"E, 1895 m elevation). The emergence lasted from 16 May to 20 June 1994. No adult emerged from infested seeds of *C. funebris* (Tab. 1). Two species of *Megastigmus* were reported to attack seeds of *Cupressus* in Eurasia, *M. cupressi* MATHUR on *C. torulosa* in East Penjab, India (MATHUR, 1955), and *M. wachtli* SEITNER on *C. sempervirens* L., *C. atlantica* GAUSS. and some exotic species of *Cupressus* introduced from North America to Europe (ROQUES *et al.*, in prep.). Comparison of adult morphology with both Mathur's description of *M. cupressi* and European specimens of *M. wachtli* revealed that the individuals from Yunnan were a new species.

Megastigmus duclouxiana ROQUES ET PAN sp.n.

♀. Length of body: 2.4-2.8 mm (without ovipositor); length of ovipositor: 2.2-2.3 mm. Body colour dark-orange. Head light- to dark-orange. Vestiture on head light. Scape, pedicel, and anneli yellowish, funicle segments dark-brown. Scape elongate, as long as combined lengths of pedicel, anneli, first funicle segment (FI), and 1/2 second funicle segment (FII) (Fig. 1). First funicle segment elongate, following segments progressively tending to subquadrate. Thorax almost entirely dark-orange but pronotum usually lighter than scutum and scutellum. Anterior suture of mid-lobe of scutum usually black. Axillae with a dark lateral spot. Wing insertion with a black spot. Metanotum and propodeum dark-orange to dark-brown. Pronotum and mid-lobe of scutum with strong transverse carinae. Frenal area limited and smooth. Vestiture on thorax light. Stigma oval, 1.6 times as long as wide, with a very short stigmal vein, as small as uncus (Fig. 9). Legs orange, with claws and hind coxa darker. Gaster blackish with lateral orange spots on proximal segments. Ovipositor shorter than body, as long as thorax and gaster combined.

♂. Length of body: 2.5-2.9 mm. Body colour darker than in female. Ventral face of body mostly black. Head with clypeal area dark-orange, remainder brown. Vestiture on head light. Scape, pedicel, and anneli yellowish, funicle segments brown. Scape slightly longer than combined lengths of pedicel, anneli, and FI

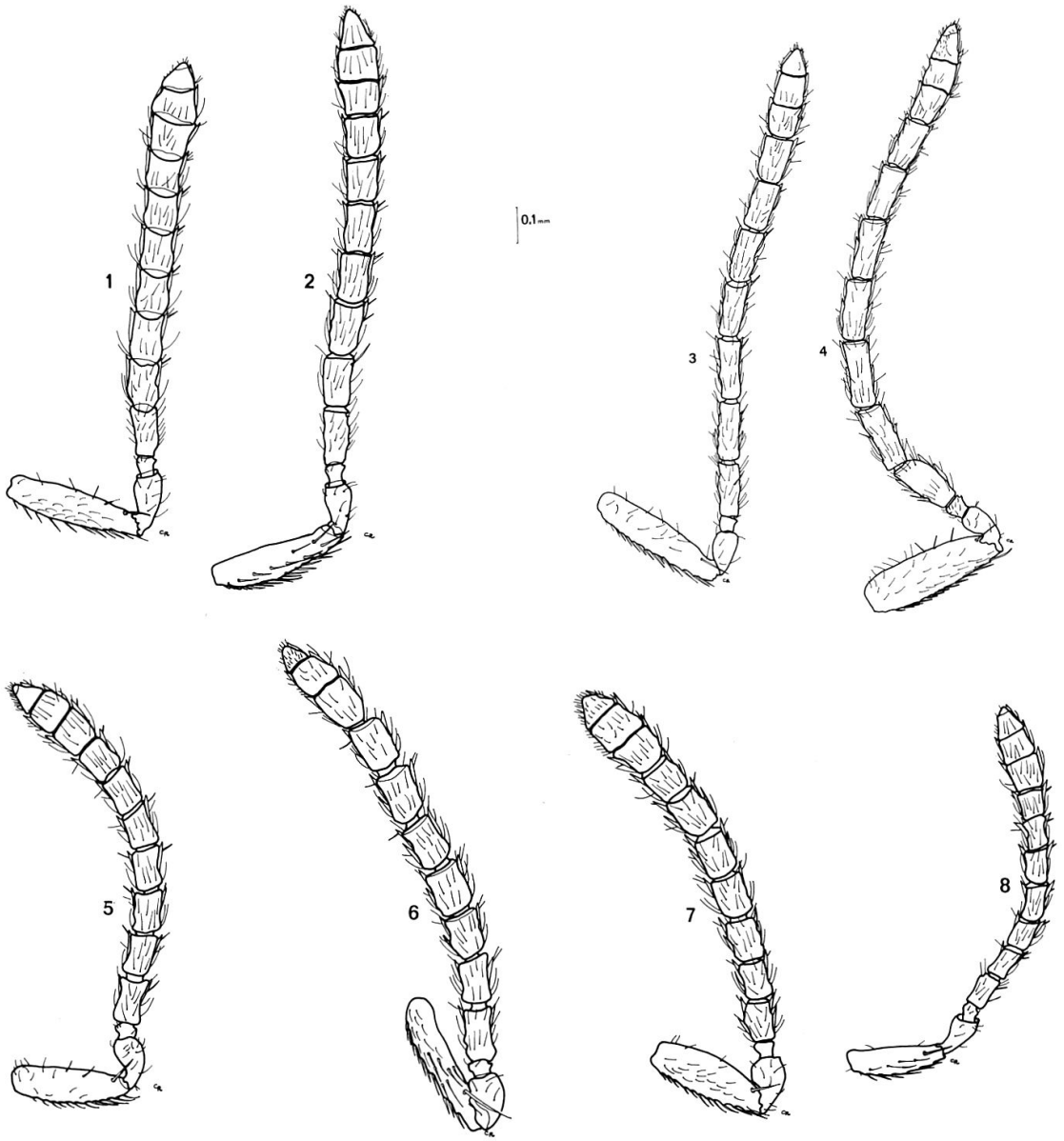
(Fig. 2). FI elongate, following funicle segments progressively tending to subquadrate. Thorax mostly dark-orange with some brown to black patterns. Scutum with anterior margin of mid-lobe and postero-lateral part of side lobes black. Prepectus black. Antero-lateral part of axillae blackish. Metanotum and propodeum dark-brown. Pronotum and mid-lobe of scutum with strong transverse carinae. Frenal area limited and smooth. Stigma oval elongate, 1.8 times as long as wide, with a very short but wide stigmal vein, smaller than uncus (Fig. 10). Legs mostly orange, coxae black, femorae with a blackish oval spot on central part (in a few cases, the spot is absent on mid femorae). Gaster black with a lateral orange spot on proximal segments.

Type material: 1 ♂ holotype and 4 ♂♂, 4 ♀♀ paratypes, Anning Hot Springs, Anning County, Yunnan, China, emerged from seeds of *Cupressus* (leg. PAN YONG-ZHI, 5.XII.1993). Holotype ♂: ex. 20.V.1994, seed of. *C. duclouxiana* (NFU, Harbin, China). Paratypes: 1 ♂, 1 ♀, ex. 20.V.1994, seed of *C. torulosa* (NFU, Harbin, China); 1 ♀, ex. 20.V.1994, seed of *C. duclouxiana* (NFU, Harbin, China); 2 ♂♂, ex. 18.V.1994, seed of *C. duclouxiana* (INRA, Orléans, France), 1 ♂, ex. 17.V.1994, seed of *C. torulosa* (INRA, Orléans, France), 2 ♀♀, ex. 20.V.1994, seed of *C. duclouxiana* (INRA, Orléans, France), 1 ♀, ex. 20.V.1994, seed of *C. torulosa* (INRA, Orléans, France). Other individuals collected in 1994 (7 ♂♂, 8 ♀♀) were used to perform comparative electrophoretic analysis among Eurasian species of *Megastigmus.*

Affinities. The species differs from *M. cupressi* in the shape of the stigma and in the thorax colour patterns. In both sexes of *M. cupressi,* the stigma is elongate whilst that of *M. duclouxiana* is oval to rounded. The faint V-shaped band observed on mid-lobe of scutum of *M. cupressi* is absent in the new species. *M. duclouxiana* is distinguished from *M. wachtli* by a darker colour and the presence of black parts on male thorax, a pale pilosity on face and thorax (black in *M. wachtli*), and a much smaller female ovipositor (longer than body in *M. wachtli*). The stigma is similar in shape in the two species but the stigmal vein is much broader in *M. duclouxiana.*

Megastigmus spp. infesting Juniperus seeds

A total of 12 adults (6♂♂, 6♀♀) emerged from seeds of *J. pingii* collected on 12 June 1993, on the lower slopes of Yulongxueshan, Lijiang, Yunnan (coordinates as above, 3050 m elevation). Emergence lasted from 12 July to 25 July 1993. Only one larva was observed in the seeds of *J. squamata* but does not turn to adult yet. In *J. sibirica*, the entire cone sample was damaged by a mite, *Trisetacus* sp. (Acarina: Eriyophiidae), whose presence might have prevented further attack by seed chalcid as it was observed in European junipers (ROQUES, 1983). Seeds of *Juniperus convallimu* REHD. ET WILS., *J. komarovii* FLORIN, *J. przewalskii* KOM., *J. tibetica* KOM., and *J. saltuaria* REHD ET WILS., have already been reported to host *M. sabinae* in Qinhai and Gansu Province of southwestern China (WU *et al.,* 1993). SAITO & YAMAMOTO (1985) recorded *Megastigmus* sp. on *J. chinensis* L. in Japan but did not give species description. In addition, *M. fidus* NIK. has been observed on *J. sibirica* in Siberia whereas 4 other *Megastigmus* species (*M. certus* NIK., *M. gravis* NIK., *M. juniperi* NIK., *M. validus* NIK.) have been recorded on several other species of junipers growing in the southern areas of the former Soviet Union (STADNITSKII *et al.,* 1978). However, the specimens from Lijiang differ from the literature description of both *M. sabinae* (XU & HE, 1989) and the Russian species (NIKOLSK'AYA, 1966).



Figs. 1-8: Antenna of *Megastigmus* species from China. 1: *M. duclouxiana* sp.n. ♀; 2: *M. duclouxiana* ♂; 3: *M. pingii* sp.n. ♀; 4: *M. pingii* ♂; 5: *M. pictus* FÖRSTER ♀; 6: *M. ezomatsuanus* HUSSEY ET KAMIJO ♀; 7: *M. likiangensis* sp.n. ♀; 8: *M. cryptomeriae* YANO ET KOYAMA ♀.

Megastigmus pingii ROQUES ET SUN sp.n.

♀. Length of body: 3.6-3.9 mm (without ovipositor); length of ovipositor: 2.5-2.7 mm. Body colour dark orange. Head yellow-orange to dark-orange, lower face usually lighter. Vestiture on lower face dark. Scape, pedicel, and anneli yellow, funicle segments dark-brown. Scape elongate, longer than combined length of pedicel, anneli, FI, and 1/2 FII (Fig. 3). Funicle segments very elongate, more than 2.5 times as long as wide, except FI. Thorax mostly orange to dark-orange but pronotum usually light-yellow (sometimes darker with a brown anterior margin). Anterior margin of mid-lobe of scutum and anterior part of side lobes dark-brown. Antero-lateral part of axillae dark-brown. Wing insertion with a dark-brown spot. Scutellum orange. Metanotum and propodeum light- to dark-orange. Vestiture on thorax dark. Frenal area smooth. Stigma oval elongate, 1.6 times as long as wide, surrounded by a yellow infuscation; stigmal vein short and broad, uncus short (Fig. 11). Legs yellow, fore coxa yellowish-brown, mid- and hind coxa brownish, hind femora with a central, oval, brown spot. Gaster dark-brown on dorsal part, orange-yellowish latero-ventrally. Ovipositor shorter than body, almost equal to thorax and gaster combined.

♂. Length of body: 3.6-3.8 mm. Body colour darker than in female. Head dark-brown with light vestiture. Scape, pedicel, and anneli yellowish, funicle segments dark-brown. Scape elongate but wider than in female, longer than combined length of pedicel, anneli, and FI (Fig. 4). Funicle segment elongate, about 2.5 times as long as wide, except the 2 last segments. Thorax orange-yellow to brown with some darker patterns. Mid-lobe of scutum orange-yellow with a large, brown spot at anterior margin that extends in a narrow longitudinal middle band to the posterior margin. Side lobes of scutum and axillae dark-brown. Scutellum orange-yellow with a middle longitudinal brown stripe above the frenal line. Frenal area entirely dark-brown. Metanotum and propodeum brown. Stigma oval elongate, 1.5 times as long as wide, surrounded by a yellow infuscation; stigmal vein short and broad, uncus short (Fig. 12). Legs yellowish but coxae brown, central parts of femorae with oval brown spot, mid- and hind tibiae brownish. Gaster shining dark-brown.

Type material: 1 ♂ holotype and 1 ♂, 2 ♀♀, Yulongxueshan, Lijiang, Yunnan, China, from seeds of *Juniperus pingii* (leg. A. ROQUES, 12.VI.1993). Holotype ♂: ex. 12.VII.1994 (NFU, Harbin, China). Paratypes: 1 ♀, ex. 15.VII.1994 (NFU, Harbin, China); 1 ♂, ex. 12.VII.1994 (INRA, Orléans, France); 1 ♀, ex. 14.VII.1994 (INRA, Orléans, France). Other individuals (4 ♂♂, 4 ♀♀) were used to perform comparative electrophoretic analysis among Eurasian species of *Megastigmus.*

Affinities. The species differed from *M. sabinae* mostly in the shape of the stigma and antennae. According to XU & HE (1989), the stigma of *M. sabinae* is much more rounded in both sexes, 1.47 times as long as wide in female and 1.2 as long as wide in male. The stigmal vein is longer and narrower in *M. sabinae*. Funicle segments of *M. pingii* antennae are more elongate in both sexes than those of *M. sabinae.*

Megastigmus spp. infesting Larix seeds

No adult of *Megastigmus* emerged in 1994 from the chalcid-infested seeds of *Larix olgensis* collected in 1993 in Changbai Mts. (1300 m altitude) by the Wangqing Forestry Bureau of Jilin Province. Similarly, no adult emerged from those of *L. principis-rupprechtii* collected in the Guandi Mts. (2000 m altitude) of Shanxi Province. By contrast, a total of 12 adults, all of them females, emerged late June 1994 from seeds of *L. gmelini* collected at Daï-ling. Those individuals were com-

pared to European specimens of *M. pictus* and to females of *M. inamurae* from Japan (1♀, Usuda, Nagano Prefecture, Honshu, ex. *Larix leptolepis*, iv.1964, K. KOBAYASHI leg.) and from the Kuriles Islands (Shikotan, 12.vi.1944, K. KAMIJO leg.). Based on the original description by YANO (1916), HUSSEY (1962) stated that the females of *M. inamurae* differentiate by a more limited black margin on the anterior part of pronotum. However, the black margin was sometimes absent in the European specimens of *M. pictus* while the darkest individuals had an extended brownish colouration on the thorax. The females from China showed highly variable colour patterns, from typical *pictus* pattern regarding pronotum to an extended brownish colouration involving mid- and side lobes of scutum, scutellum, and axillae with yellow stripes limited to a transverse band on scutellum and an oblique one at inner margin of axillae. We referred the Chinese specimens to *M. pictus* but no stable difference indeed appeared between *M. pictus* and *M. inamurae*. The description of the Chinese specimens is the following.

Megastigmus pictus FÖRSTER

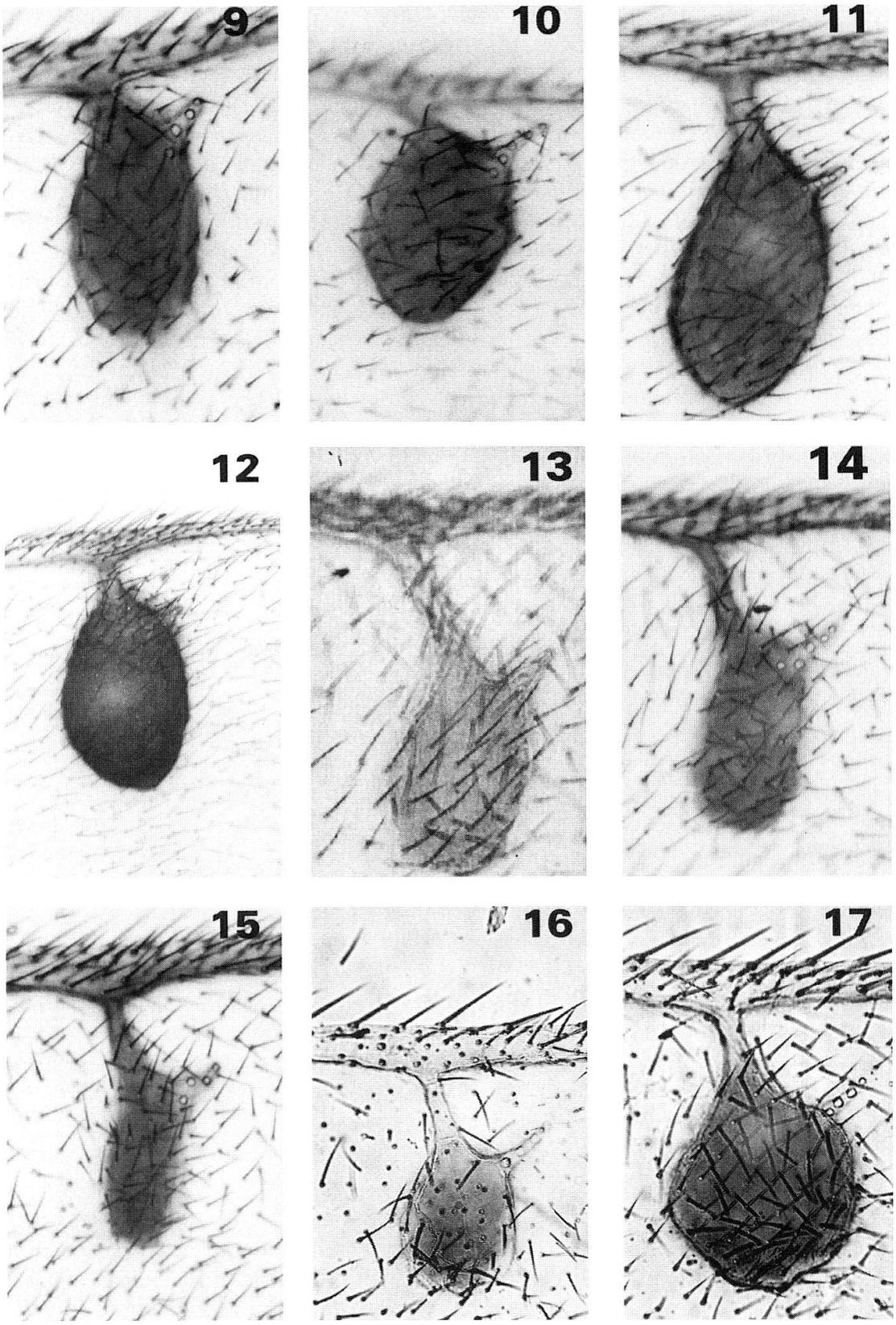
♀. Length of body: 1.9-3.3 mm (without ovipositor); length of ovipositor: 1.4-2.8 mm. Body colour black with yellow-brown patterns. Face yellow. Head in dorsal view strongly narrowed behind the eyes, with very protruding eyes. Antennae yellow to brownish. Scape elongate, much longer than pedicel, anneli, and FI combined, following funicle segments about twice as long as broad (Fig. 5). Pronotum yellowish, the anterior margin with a more or less important dark-brown spot in the middle that usually continues in a dark median band narrowing towards the posterior margin. This median band may be absent in lightest specimens. Mid-lobe of scutum brownish-black to black, remainder yellowish with a large, brown spot that extends to the axillae. Scutellum colour varying from brownish-black with two anterior lateral yellow spots to yellowish with a median longitudinal brown band crossed in its posterior part by a transverse brown band. Wings intensively hairy, forewing stigma elongate oval with an elongate stigmal vein (Fig. 13). Legs mostly yellow-brown. Propodeum black with delicate lateral and median carinae. Gaster terga black with yellow median area on lateral parts that extend in narrow dorsal bands on posterior terga. Ovipositor sheaths black. Ovipositor shorter than body, as long as thorax and gaster combined.

♂. Not observed in China, yet. Males are very scarce in Europe (0.64% of the individuals; SKRZYPCZYNSKA, 1981), the species reproducing by thelytokous parthenogenesis.

The species has been observed all over the Palearctic, from Great Britain to Far Eastern Asia, attacking seeds of most Eurasian larch species in their native range, i.e. *Larix decidua* MILL., *L. decidua* var. *polonica* RAC., *L. gmelini*, *L. sibirica* LEDEB., *L. sukaczewii* DYLIS. *M. pictus* also colonized seeds of the same larch species planted outside the natural range, additionally attacking the Japanese larch, *L. leptolepis* (SIEB. ET ZUCC.), and hybrids, *L. x czekanowski* and *L. x eurolepis* HENRY (ROQUES *et al.*, in prep.). The larvae observed during our survey of *L. olgensis* and *L. principis-rupprechtii* may therefore be *M. pictus*, too.

Megastigmus spp. infesting Picea seeds

Only one female emerged 18 April 1994 from the chalcid-infested seeds of *P. likiangensis* that were provided by the Lijiang Forestry Bureau in 1993. Another female was caught on 12 June 1993 when ovipositing on a cone of *P. likiangensis*



Figs. 9-17: Forewing stigma of *Megastigmus* species from China. 9: *M. duclouxiana* sp.n.♀; 10: *M. duclouxiana* ♂; 11: *M. pingii* sp.n. ♀; 12: *M. pingii* ♂; 13: *M. pictus* FÖRSTER ♀; 14: *M. ezomatsuanus* HUSSEY ET KAMIJO ♀; 15: *M. likiangensis* sp.n. ♀; 16: *M. cryptomeriae* YANO ET KOYAMA ♀.; 17: *M. cryptomeriae* ♂.

in a mixed larch-spruce stand of the lower slopes of Yulongxueshan, Lijiang, Yunnan (same coordinates as above, 3000 m elevation). No adult emerged from chalcid-infested seeds of *Picea koraiensis* yet, but we collected a female of *Megastigmus* ovipositing on cones of this tree species at MoErShan, Heilongjiang (45°23'N, 127°32'E, 370 m elevation) on 4 June 1993. Two species of *Megastigmus* have already been recorded from spruce seeds in Asia, *M. ezomatsuanus* HUSSEY ET KAMIJO in seeds of *Picea ghlenii* (Fr. SCHMIDT) MAST. and *P. jezoensis* CARR. in Japan (HUSSEY & KAMIJO, 1958; KAMIJO, 1962; KOBAYASHI, 1981), and *M. strobilobius* RATZ. in seeds of *Picea obovata* LEDEB. in Siberia (STADNITSKII *et al.*, 1978). In addition, *M. strobilobius* was observed to colonize seeds of two spruce species of Western China, *P. asperata* PATSCHKE and *P. montigena* MAST., when these trees were introduced to Western Europe (ROQUES *et al.*, in prep.).

Comparisons with specimens of *M. ezomatsuanus* from Hokkaido, Japan, showed that the female caught on *Picea koraiensis* likely belongs to this species. We noticed only a few differences in morphology that have to be confirmed by the examination of a larger series of individuals. By contrast, the two females from Yunnan largely differed from both *M. ezomatsuanus* and European specimens of *M. strobilobius*. A new species, *M. likiangensis* sp.n., is described. Following are the descriptions of the Chinese specimens.

Megastigmus ezomatsuanus HUSSEY ET KAMIJO

♀. Length of body: 1.6 mm (without ovipositor); length of ovipositor: 1.5 mm. Body colour mostly shining black. Lower face of head yellow with dark vestiture; eye surrounded by a yellow band interrupted by black on internal side. Antennae light brown. Scape very elongate, as long as combined lengths of pedicel, anneli, FI, and 2/3 FII (Fig. 6). Pedicel smaller but wider than FI. Last funicle segments quite subquadrate. Thorax mostly shining black with a few yellow patterns. Pronotum with a transverse, yellowish band at posterior margin. Prepectus yellow. Insertion of forewing with a yellowish spot. Frenal area smooth. Propodeum with a weak but complete median carina. Stigma elongate, 1.77 times as long as wide (Fig. 14). Legs mostly yellowish except mid- and hind coxa black. Gaster black with latero-ventral parts yellowish. Ovipositor shorter than body, as long as thorax and gaster combined.

Body colour is similar in the specimens of *M. ezomatsuanus* from Japan, but the antennal scape is slightly less elongate, as long as combined lengths of pedicel, anneli, FI, and 1/2 FII. The median carina of propodeum is stronger. The ovipositor is a bit smaller than that of the Chinese specimen.

Megastigmus likiangensis ROQUES ET SUN sp.n.

♀. Length of body: 2.3-2.4 mm (without ovipositor); length of ovipositor: 2.6-2.7 mm. Body colour shining black. Lower face of head yellow with dark vestiture; eye surrounded by a yellow band; vertex black. Antennae dark-brown. Scape elongate, equal to combined lengths of pedicel, anneli, FI and 1/2 FII. Pedicel equal to FI. FI elongate, following segments progressively tending to subquadrate (Fig. 7). Thorax shining black with some yellowish patterns. Posterior margin of pronotum with two transverse dirty yellow spots. Axillae with a lateral yellow spot extending on antero-lateral parts of scutellum. Anterior margin of dorsellum of metanotum with a narrow, transverse, yellowish band. Sides of propodeum yellowish. Frenal

area smooth. Propodeum with a strong, median carina. Legs yellowish except hind coxa blackish. Stigma very elongate, 2.1 times as long as wide, uncus angle to stigma almost 90° (Fig. 15). Gaster black with lateralo-ventral parts yellowish. Ovipositor longer than body.

Type material: 1 ♀ holotype and 1 ♀ paratype, Yulongxueshan, Lijiang, Yunnan, China, from seed of *Picea likiangensis.* Holotype ♀: ex. 18.IV.1994 (leg. A. ROQUES, 12.VI.1993) (NFU, Harbin, China). Paratype ♀: caught on cone of seed of *P. likiangensis* (leg. SUN JIANG-HUA, 12.VI.1993) (INRA, Orléans, France).

Affinities. The species is distinguished from *M. ezomatsuanus* by the thorax colour and, essentially, by the length of the ovipositor (shorter than body in *M. ezomatsuanus*). *M. likiangensis* also differs from *M. strobilobius* in the shape of the stigma (oval-elongate in *M. strobilobius*), the thorax colour patterns (thorax quite entirely black except two yellow spots on pronotum in *M. strobilobius*), and the sculpture of the frenal area (smooth in *M. strobilobius*) (ROQUES *et al.*, in prep.).

Megastigmus spp. infesting Pseudotsuga seeds

A larva of *Megastigmus* was observed in seeds of *P. sinensis* collected on 5 December 1993 about 100 km of Anning Hot Springs (same coordinates as above), Yunnan, at 2000 m elevation. Unfortunately, the larva remained in prolonged diapause in 1994 and the adult could not be identified, yet. Males and females of a species, *Megastigmus* sp., were observed emerging from seeds of *P. gaussenii* at Huangshan, Anhui Province (ZHOU, 1978) but the description of adult morphology was limited. It would be interesting to compare adult specimens from Chinese *Pseudotsuga* to the Douglas-fir seed chalcid, *Megastigmus spermotrophus* WACHTL, that has been introduced all over the world with the seeds of its North American host, *P. menziesii* (MIRB.) FRANCO (MILLIRON, 1949). According to ZHOU (1978), females from Anhui presented an ovipositor slightly shorter than body, whereas that of *M. spermotrophus* is as long or longer than body (ROQUES *et al.,* in prep.).

Megastigmus spp. infesting Rosa seeds

No adult of *Megastigmus* emerged either in 1993 nor in 1994 from the infested seeds of *R. acicularis* collected at MoErShan (same coordinates as above), Heilongjiang, on 5 June 1993. MILLIRON (1949) recorded that individuals of the worldwide species, *M. aculeatus*, specific to *Rosa* seeds, have been found at Beijing and Tianjin.

Megastigmus spp. infesting Cryptomeria seeds

Chinese species of *Cryptomeria* were not surveyed during the study but stigma and antennae of *M. cryptomeriae*, emerged on 15 April 1990 from seeds of *C. fortunei* HOOB., collected at Huang-yan County, Zhejiang (Zhi-hua He leg.), are shown for comparison (Fig. 8 and Figs 16-17). Detailed description of Chinese specimens of *M. cryptomeriae* was given by HE (1984).

CONCLUSION

At present, a total of 9 *Megastigmus* species have been identified to damage seeds in China. It is likely that the real number of *Megastigmus* species developing in tree seeds is much more important. Some of the larvae we found in *Abies delavayi, Juniperus squamata, Pseudotsuga sinensis,* at least, probably correspond to addi-

tional *Megastigmus* species. With regard to the position of Chinese regions as centres of origin and diversification for many conifer genera, a larger survey of seed insects in Chinese conifers could be expected to provide important information about evolutionnary relationships between seed insects and conifers as well as about *Megastigmus* phylogeny. A focus on tree species belonging to relictuous or isolated genera like *Cunninghamia, Glyptostrobus, Keteleeria, Metasequoia* may be particularly interesting.

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RÉSUMÉ

On a inventorié, en 1993-94, les espèces de chalcidiens du genre *Megastigmus* susceptibles d'attaquer les graines de 16 espèces de conifères et 2 espèces de *Rosa* en Chine. La radiographie des graines a révélé des larves de *Megastigmus* dans 14 des espèces végétales étudiées. Dans quelques cas, ces larves sont restées en diapause prolongée pendant toute la durée de l'étude, et les adultes n'ont pu être précisément identifiés. Trois espèces de *Megastigmus* nouvelles pour la science ont été décrites dans les graines de *Cupressus* spp., *Juniperus pingii*, et *Picea likiangensis,* récoltées dans la province du Yunnan. De plus, une espèce de *Megastigmus* précedemment signalée du Japon a été observée dans les graines de *Picea koraiensis* dans la province du Heilongjiang. Au total, 9 espèces de *Megastigmus* sont maintenant connues en Chine.

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