Indigenous and introduced seed chalcids in Denmark – with a revised key to the Danish species
(Hymenoptera: Torymidae)

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The paper describes the occurrence and host relationship of Danish species of *Megastigmus* Dalman, 1820. Five species are new to the Danish list, viz. *M.atedius* Walker, 1851, *M.milleri* Milliron, 1949, *M.rafni* Hoffmeyer, 1929, *M.specularis* Walley, 1932 and *M.borriesi* Crosby, 1913. They are all introduced. The indigenous species *M.bipunctatus* (Swederus, 1795) is now represented by specimens from known localities. The routes of introduction and response to host plants are discussed.

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Introduction

Seed chalcids belong to a group of seed-consuming insects that feed on the inner part of seeds during the larval period. Systematically, they form part of the genus *Megastigmus* Dalman, 1820, which comprises about 85 species worldwide. Some *Megastigmus* species are, however, parasitoids, mainly on cynipids associated with oak.

In Denmark, Jespersen & Lomholdt (1983) described the known Danish material and also included notes on the general biology of seed chalcids and their pest status. They listed nine species, one of which is an indigenous parasitoid, three are indigenous granivores on Rose (*Rosa canina*), Juniper (*Juniperus communis*) and Rowan (*Sorbus aucuparia*), and five introduced species that are associated with conifers. The juniper chalcid, *M. bipunctatus* was only represented by material of unknown origin. Since 1983, intensive investigations have been carried out and more than five hundred seed and cone samplings have been made, with main emphasis on introduced conifers (Jensen & Ochsner, 1996; Iversen & Jensen, 1997; Jensen & Larsen, 1997; Ochsner & Jensen, 1997). Five species new to the Danish list can be recorded, (six if *M.bipunctatus* is included), viz. *M. atedius* Walker, 1851; *M.milleri* Milliron, 1949; *M.rafni* Hoffmeyer, 1929; *M.specularis* Walley, 1932 and *M.borriesi* Crosby, 1913. They will be diagnosed in the present paper along with a revised key to the Danish species. Notes on their local distribution and host relations are also presented.

Key to the Danish species of *Megastigmus* Dalman

Species of *Megastigmus* are readily recognized by the very enlarged stigma on the forewing (Fig. 1A). No other Danish chalcids possess a similar character. They are generally small species, up to 6 mm in total body length, and show extreme intra-specific variability in size,

so that very small specimens appear along with large specimens in rearings from the same seed sample. The size ranges given are body lengths. The majority of the measurements are taken from Boucek (1970), others are own measurements. Females are easily distinguished from males by their clearly prominent ovipositor, which is at least one third of the body length. The nomenclature follows Milliron (1949), Boucek (1970) and Yates (1986).

Males

1a. Thorax dorsally with greenish metallic colour *M.dorsalis*

1b. Thorax without metallic colour 2

2a. Colour of mesoscutum and/or scutellum predominantly black 3

2b. Colour of mesoscutum and/or scutellum predominantly brown or yellow 8

3a. Thorax with pale soft hairs *M.pinus*

3b. Thorax with black hairs 4

4a. Hairs on lower face below antennae mainly dark *M.suspectus*

4b. Hairs on lower face below antennae mainly pale 5

5a. Pedicellus shorter than ring segment and first funicle segment together 6

5b. Pedicellus as long as or longer than ring segment and first funicle segment together (Fig. 1C) 7

6a. Mid part of metanotum yellow; anterior margin of scutellum shorter than posterior margin of mesopraescutum *M.milleri*

6b. Mid part of metanotum black; anterior margin of scutellum wider than posterior margin of mesopraescutum *M.specularis*

7a. Pronotum with two dorso-lateral, oblique, light spots; hind part of median lobe of mesoscutum generally only showing cross-striations *M.atedius*

7b. Pronotum with a pale narrow band in front of hind margin; hind part of median lobe of mesoscutum with some medial longitudinal striae *M.strobilobius*

8a. Thorax mainly brownish black, only pronotum more or less yellowish 9

8b. Dorsal part of thorax mainly yellow 11

9a. Flagellum about as long as width of head, middle funicle segments subquadrate; head in dorsal view hemispherical *M.brevicaudis*

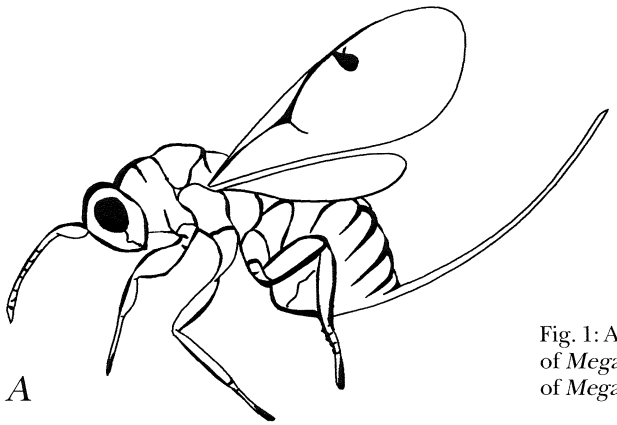
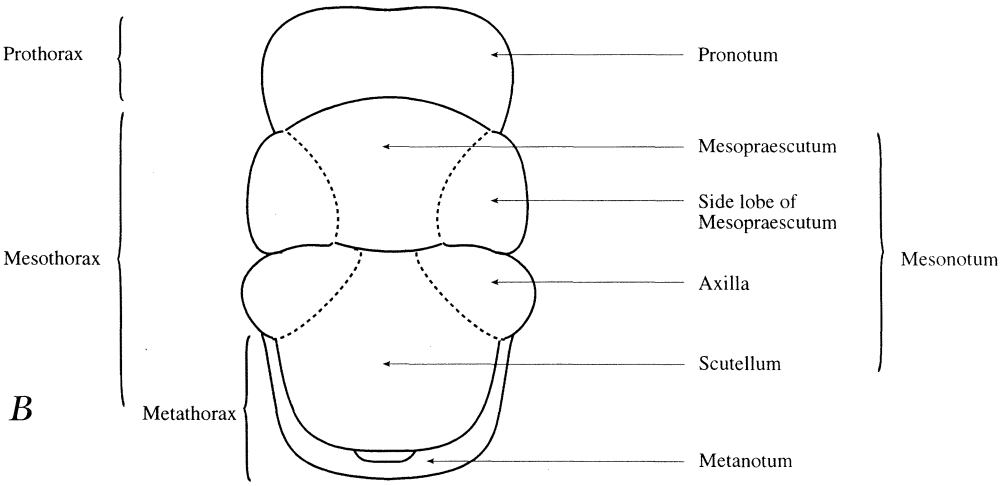
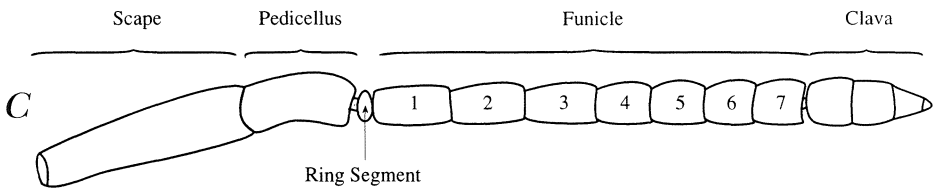


Fig. 1: A, female of *Megastigmus* sp.; B, thorax of *Megastigmus* sp. in dorsal view; C, antenna of *Megastigmus* sp. in lateral view.





9b. Flagellum longer than width of head, all funicle segments elongate; head in dorsal view much wider than long 10

10a. Head strongly narrowed behind the eyes *M.pictus*

10b. Head not strongly narrowed behind the eyes *M.bipunctatus*

11a. Stigmal vein very short, shorter than stigma width; vertex flattened *M.aculeatus*

11b. Stigmal vein longer, about as long as stigma; vertex convex 12

12a. Hind tarsus distinctly longer than two thirds of hind tibia; proximal segments of funiculus of equal size, twice as long as wide; propodeum usually black anteriorly *M.rafni*

12b. Hind tarsus nearly two thirds as long as hind tibia; only first funiculus segment twice as long as wide; propodeum yellow or brownish yellow *M.spermotrophus*

Females

1a. Thorax dorsally with greenish metallic colour *M.dorsalis*

1b. Thorax without metallic colour 2

2a. Ovipositor sheath shorter than gaster 3

2b. Ovipositor sheath longer than gaster 4

3a. Thoracic dorsum mainly yellow; pronotum slightly wider than long; stigma large, oval *M.bipunctatus*

3b. Thorax mainly brownish black, only pronotum more or less yellow; pronotum distinctly wider than long; stigma oblong with a very short uncus *M.brevicaudis*

4a. Ovipositor sheath shorter than thorax plus gaster 5

4b. Ovipositor sheath longer than thorax plus gaster 7

5a. Mid lobes of mesoscutum brownish black, side lobes pale brownish or yellowish; two yellow spots in axillar furrows extending on surrounding scutellum *M.pictus*

5b. Body black except for yellow parts on pronotum 6

6a. Pronotum with two light, oblique dorso-lateral spots *M.atedius*

6b. Pronotum with a narrow, light band across front margin *M.strobilobius*

7a. Hairs dorsally on thorax mainly soft and pale *M.pinus*

7b. Hairs on thorax black 8

8a. Hairs on lower face below antennae mainly black; stigma very elongate *M.suspectus*

8b. Hairs on lower face below antennae mainly pale; stigma oval 9

9a. Body colour predominantly yellow or brownish yellow 10

9b. Body colour predominantly black or dark brown 12

10a. Stigma with a very short uncus *M.aculeatus*

10b. Stigma with a long uncus 11

11a. Hind tarsus about three quarters as long as hind tibia *M.rafni*

11b. Hind tarsus about two thirds as long as hind tibia *M.spermotrophus*

12a. Pronotum yellow, except for two black spots, rest of thorax dorsally yellow *M.milleri*

12b. Pronotum predominantly black 13

13a. Pronotum black except for two small, transverse, yellow spots *M.specularis*

13b. Pronotum all black *M.borriesi*

List of *Megastigmus* species in Denmark

In the following we provide brief information on diagnostic characters of the species, host-plant relations, Danish records and zoogeographic region of origin.

Megastigmus dorsalis (Fabricius, 1798)
– *Diagnosis.* – The only Danish *Megastigmus* with a distinct metallic, golden green colour dorsally on thorax. Stigma oval, surrounded by infumation. Ovipositor slightly longer than abdomen; male 1.3-4.3 mm, female 1.4-5.3 mm.
– *Hosts.* – *M.dorsalis* is the only Danish *Megastigmus* which is a parasitoid. It has been reared from galls of *Andricus* spp. on oak (*Quercus*). It has not been found in the present investigation.
– *Danish records.* – NEJ: Børglumkloster Skov. NWZ: Bromme, Bildsø. NEZ: Charlottenlund. SZ: Korsør, Holsteinsborg, Skælskør, Basnæs, Billesborg (Jespersen & Lomholdt, 1983).
– *Origin.* – West Palaearctis. Indigenous.

M.aculeatus (Swederus, 1795)
– *Diagnosis.* – Body yellow-brown; thorax brown, pronotum and scutellum yellow, mesoprescutum yellow but brown anteriorly, propodeum at least anteriorly black, axillae, anterior part of mesoscutum and vertex usually partly black. Males extremely rare; colour pattern similar to that of female; male 2.5-3.2 mm, female 2.6-3.8 mm.
– *Hosts.* – Found on indigenous roses, mainly *Rosa canina.*

– *Danish records.* – Widespread and common. EJ: Linå Vesterskov, Langå, Ry, Skibet, Mariager, Femmøller, Søvind. NEJ: Rebild Bakker. NWZ: Bromme, Sjællands Odde. NEZ: Vaserne, Strødam.
– *Origin.* – Holarctis. Indigenous.

M.brevicaudis Ratzeburg, 1848
– *Diagnosis.* – Thorax generally brownish black, only pronotum more or less yellow. Ovipositor at most 1.3 times as long as hind tibia. Flagellum in female about as long as width of head, in both sexes middle funicle segments subquadrate; male1.2-2.7 mm, female1.6-2.2 mm.
– *Hosts.* – Larvae live in seeds of Rowan (*Sorbus aucuparia*).
– *Danish records.* – Few records from Denmark. Not found in the present investigation. NEZ: Utterslev Mose. SZ: Korsør, Basnæs (Jespersen & Lomholdt, 1983).
– *Origin.* – Holarctis. Indigenous.

M.bipunctatus (Swederus, 1795)
– *Diagnosis.* – Thorax in female predominantly yellow, but darker in large specimens, male distinctly black, but scutellum anteriorly mainly yellow. Flagellum in female longer than width of head, middle funicle segments elongate. Ovipositor up to 1.5 times as long as hind tibia; male 1.8-4.0 mm, female 1.8-3.1 mm.
– *Hosts.* – In seeds of Juniper (*Juniperus communis*). Females mainly lay eggs in the green 3-year old berries (Göttsche, 1977), and emergence holes can be seen in blue 3-year old berries.
– *Danish records.* – First Danish records with known locality. EJ: Femmøller, Høvild Skov, Ø Bakker, Randbøl. WJ: Vindblæs.
– *Origin.* – West Palaearctis. Indigenous.

M.pictus (Förster, 1841)
– *Diagnosis.* – Body dark, mesoscutum in females with mid lobes all brownish black, side lobes often paler brownish; in males yellow colour more extended; two round yellow spots in axillar furrows. Ovipositor at most as long as thorax plus gaster; male 2.7 mm, female 2.5-3.2 mm.
– *Hosts.* – In seeds of European Larch (*Larix decidua*). Not known whether hybrid larch (*Larix decidua* x *kaempferi* = *Larix* x *eurolepis*), which is widely used in Denmark, is a suitable host.
– *Danish records.* – Rather few recent records, apparently uncommon. NEJ: Skovhaven. EJ: Hagsholm Skov, Ry, Frijsenborg, Skramsø Plantage. Older records: NEJ: Buderupholm. NEZ: Rude Hegn. SZ: Lellinge Skov, Digmose Skov (=Viemose Skov?), Tågerød Skov, Valdemarslund. B: Rø Plantage (Jespersen & Lomholdt, 1983).
- *Origin.* - West Palaearctis. Introduced to Denmark.

M.spermotrophus Wachtl, 1893
– *Diagnosis.* – Females: thorax and propodeum generally yellow or yellow-brown; stigma elongate; first hind tarsal segment approximately 1 1/3 x as long as second; ovipositor sheath at most as long as body. In male colour mostly lemon yellow, abdomen brownish yellow; hind tarsus almost two thirds as long as hind tibia; first hind tarsal segment up to 1.7 x the second; male 2.7-3.8 mm, female 2.8-4.3 mm.
– *Hosts.* – In Denmark only reared from Douglas Fir (*Pseudotsuga menziesii*) seeds. Old records also mention certain *Abies* species as hosts, but this is probably a misidentification; see *M.rafni* (Milliron, 1949).
– *Danish records.* – Common in areas where Douglas Fir is planted: EJ: Addit Skov, Bjerre

Skov, Jelling Skov, Munkebjerg, Ry, Silkeborg Nordskov, Frijsenborg, Skramsø Plantage, St.Hjøllund Plantage, Søvind Skov. F: Langesø, Wedelsborg, Hvidkilde, Fåborg, Krengerup. NEZ: Mosskovgård, Valdemarslund, Klosterris Hegn. SZ: Suserup Skov, Svenstrup Enghave, Gjorslev.
– *Origin.* – Nearctis. Introduced to Denmark.

M.atedius Walker, 1851
– *Diagnosis.* – Thorax generally black, in females tegulae mesially yellowish. Pronotum usually with two dorsal, slightly transverse, pale spots. Body finely sculptured, mid lobe of mesoscutum also posteriorly cross-striate. Abdomen generally dark brown - black, sterna somewhat lighter; male 1.9-3.4 mm, female 1.9-3.8 mm.
– *Hosts.* – Reared from seeds of Sitka Spruce (*Picea sitchensis*), Serbian Spruce (*Picea omorika*) and Oriental Spruce (*Picea orientalis*). Not reared from Norway Spruce (*Picea abies*). Infection rates of 2-8% recorded (Lund, 1997).
– *Danish records.* – First Danish records. Widespread and common in locations where Sitka Spruce is planted. NEJ: Borup Hede, Fosdalen. WJ: Havredal Plantage, Kompedal Plantage. EJ: Jelling Skov, Linå Vesterskov, Silkeborg Nordskov, Silkeborg Østerskov, Frijsenborg, Rye Nørreskov, Skramsø Plantage, Søvind Skov, Tirstrup Plantage, Norring Skov, Forstbotanisk Have (Århus), Åkjær. F: Ørslev Bjerge, Langesø, Wedelsborg. SZ: Fensmark.
– *Origin.* – Nearctis. Introduced to Denmark.

M.strobilobius Ratzeburg, 1848
– *Diagnosis.* – Thorax generally black. Pronotum usually with a pale translucent cross-band in front of hind margin, sometimes narrowly interrupted in the middle; side of pronotum pale. Mid lobe of mesonotum often with longitudinal striae posteriorly; male 2.3-3.0 mm, female 2.4-3.0 mm.
– *Hosts.* – Associated with seeds of Norway Spruce (*Picea abies*), but not found in present investigation. At low infestation rates in other parts of Europe (Skrzypczynska & Roques, 1987).
– *Danish records.* – Few, old records from Denmark. SZ: Haslev, Lellinge.
– *Origin.* – West Palaearctis. Introduced to Denmark.

M.pinus Parfitt, 1857
– *Diagnosis.* – Body black and yellow. Colour pattern in female very variable, most large females having a very large orange-yellow spot dorsally on thorax; males black except yellow on side of pronotum and two irregularly shaped spots on latero-posterior margin of dorsum. Both females and males have pale, thin, bending hairs dorsally on thorax, hairs of lower part of face also pale. One of the largest seed chalcids, male 2.6-4.5 mm, female 2.8-5.6 mm.
– *Hosts.* – Found on a large number of introduced Fir (*Abies*) species. The only *Megastigmus* found on Noble Fir (*A.procera*), where it infects up to 98% of the seeds (Jensen & Ochsner, 1996).
– *Danish records.* – Widespread and common. NEJ: Tingskov, Rold Skov. WJ: Ulfborg Plantage, Ulvedal Plantage. EJ: Linå Vesterskov, Hejnæs, Frijsenborg, Hagsholm Skov, Gl.Rye, Overgaard, Pøt Mølleskov, Velling Skov, Lyngballe Skov, Lystrup Skov, Norring Skov, Bjerre Skov, Fajstrup Skov, Silkeborg Vesterskov, Silkeborg Østerskov, Søvind Skov. F: Langesø, Krengerup. NEZ: Klosterris Hegn, Krogerup. SZ: Sorø.
– *Origin.* – Nearctis. Introduced to Denmark.

M.milleri Milliron, 1949
– *Diagnosis.* – Large females black and yellow, smaller females more brownish. Pronotum

almost entirely yellow, scutellum entirely yellow except for anterior median black spot. Males generally black, but sides of pronotum, outer surface of mesoscutum and a spot under front wing base yellow. Thoracic hairs black; male 2.0-3.3 mm., female 3.0-4.2 mm.
– *Hosts.* – Main host seems to be Grand Fir (*Abies grandis*) but *M.milleri* has also been recorded from a number of other introduced *Abies* species, however not from Noble Fir (*A.procera*) (Ochsner & Jensen, 1997).
– *Danish records.* – First Danish records. Widespread and common where *Abies* is planted. NEJ: Rold Skov, Tingskov. WJ: Ulvedal Plantage. EJ: Fløjstrup Skov, Høvild Skov, Lyngballe Skov, Frijsenborg, Linå Vesterskov, Pøt Mølleskov, Norring Skov, Skramsø Plantage, Velling Skov, Silkeborg Sønderskov. F: Langesø. NEZ: Horserød Hegn, Klosterris Hegn.
– *Origin.* – Nearctis. Introduced to Denmark.

M.rafni Hoffmeyer, 1929
– *Diagnosis.* – Colour in males mostly brownish yellow with dark brown or black markings; in females colour varies from yellow (greenish or brownish) with dark brown or black markings to almost entirely brownish yellow; ovipositor sheath longer than body; in females first segment of hind tarsus approximately twice as long as second segment; in males hind tarsus longer than two thirds of hind tibia; male 2.0-3.0 mm, female 3.0-4.2 mm.
– *Hosts.* – Occurs on a large number of introduced *Abies* species, e.g. Caucasian Fir (*A.nordmanniana*), but not on Noble Fir (*A.procera*); generally with low infestation rates.
– *Danish records.* – New species to Denmark. Widespread and common where *Abies* is planted. NEJ: Skovhaven. WJ: Ulvedal Plantage, Nørlund. EJ: Høvild Skov, Bjerre Skov, Fajstrup Krat, Frijsenborg Sønderskov, Norring Skov, Pøt Mølleskov, Jelling Skov, Linå Vesterskov, Lyngballe Skov, Lystrup Skov, Rathlousdal, Silkeborg Vesterskov, Silkeborg Østerskov, Skramsø Plantage, Søvind Skov, Velling Skov. F: Ørslev Bjerge, Langesø. NEZ: Klosterris Hegn.
– *Origin.* – Nearctis. Introduced to Denmark.

M.specularis Walley, 1932
– *Diagnosis.* – Female: stigma oval. Hairs on lower face, sides of pronotum and gaster pale. Pronotum dorsally at hind margin usually with two transverse yellow spots; male 2.1-3.0 mm, female 2.2-3.8 mm.
– *Hosts.* – Associated with *Abies* and occurs on many species, especially of Asian origin.
– *Danish records.* – New species to Denmark. NEJ: The Arboretum "Den jyske Skovhave" in Rold Skov. EJ: Silkeborg Østerskov. NEZ: Arboretet, Hørsholm.
– *Origin.* – Holarctis. Introduced to Denmark.

M.borriesi Crosby, 1913
– *Diagnosis.* – Female: thorax, head and femur black, abdomen brown. Ovipositor longer than body. Female 2.4-3.7 mm, male not known (Kamijo, 1962).
– *Hosts.* – Reared from Veitch's Silver Fir (*Abies veitchii*).
– *Danish records.* – New species to Denmark. Only found in very low numbers in NEJ: The Arboretum "Den Jyske Skovhave" in Rold Skov.
– *Origin.* – East Palaearctis. Introduced to Denmark.

M.suspectus Borries, 1895
– *Diagnosis.* – Females large, thorax black, stigma narrow, shield-shaped. Hairs on lower face and on thorax black. Pronotum dorsally black. Ovipositor longer than body. Males only found in extremely low numbers, less than one percent. Males resemble females in coloration and has a slightly more rounded stigma (Skrzypczynska, 1978); male 3.5-3.7 mm, female 3.5-4.5 mm.

– *Hosts.* – Predominantly found in *Abies* species of Eurasian origin (Ochsner & Jensen, 1997). Original host is probably the European Silver Fir, *Abies alba.*
– *Danish records.* – Widespread and common. NEJ: Lilleheden Klitplantage, Tingskov, Rold Skov. WJ: Ulvedal Plantage, Ilskov, Gødding Skov. EJ: Høvild Skov, Frijsenborg, Jelling Skov, Linå Vesterskov, Lyngballe Skov, Rathlousdal, Norring Skov, Silkeborg Vesterskov, Silkeborg Østerskov, Søvind Skov, Randbøl, Lystrup Skov, Velling Skov, Bjerre Skov. F: Ørslev Bjerge. NEZ: Klosterris Hegn, Vaserne. SZ: Lellinge. B: Almindingen.
– *Origin.* – West Palaearctis. Introduced to Denmark.

Discussion

At the moment the indigenous Danish seed chalcid fauna comprises four species. We can not expect to find many more as few other seed-eating *Megastigmus* with host plants native to Denmark are found in neighbouring countries. One more parasitoid, *M.stigmaticans* (Fabricius, 1798) could be expected to turn up, as the hosts, gall-wasps of the genus *Andricus* are found. The main host, *A.kollari* has only recently been found in Denmark (Jensen & Nielsen, 1996).

Among the three indigenous seed-eaters, *M.aculeatus* is by the far the most common and widespread. It has been found on isolated roses in open countryside, demonstrating the dispersal abilities of the species. In this investigation it has only been found in *Rosa canina* seeds but it might well be found in other indigenous or introduced *Rosa* species, as the list of hosts is very long (Milliron, 1949). It is interesting to notice that it has not been found in *Rosa rugosa*, a widespread and common introduced species. An explanation could be the large size of the rose hip in relation to the size of the ovipositor of the seed chalcid.

The juniper seed chalcid, *M.bipunctatus* has only been found in a few locations. In a number of other locations emergence holes were observed in old, blue berries, the size of the holes indicating that they were caused by this seed chalcid. In rearings the number of specimens has also been low. Göttsche (1977) indicates that infested berries shall be picked very late in spring in order to provide imagines. Thus in the present status, the number of localities may be underestimated.

A similar problem relates to rearing of the rowan chalcid, *M.brevicaudis,* as berries are difficult to find in spring because most of them have been eaten by birds. Nalepa & Piper (1994) found that the seed chalcid *M.aculeatus nigroflavus* is able to withstand passage through the gut of birds. It can be speculated whether passage through the gut is a prerequisite for the emergence of the rowan seed chalcids.

A higher number of introduced seed chalcids were found in the present investigation compared with the list provided by Jespersen & Lomholdt (1983). This reflects primarily higher sampling intensity, including sampling of seeds from introduced plant species not normally of forestry interest. It also reflects the assumption that the number of introduced species is expected to increase as seed import increases. However, as the insects in question are associated with large tree species which first reproduce at an age of at least 20-25 years, establishment of new species of these seed insects require a number of specific conditions: firstly, seeds should be infested with the particular insect species and sown in nurseries; secondly host trees should be available in the neighbourhood and thirdly in the year of sowing host trees should flower. The latter condition is not met each year as these longlived forest trees set seeds at irregular intervals, often up to five years.

The problem of host trees depend on the specificity of the insect. In general seed chalcids are mono- to oligophagous (Turgeon *et al.*, 1994) and at least require host trees to be of the same genus. Some are, however, only able to attack certain tree species within a genus. Ochsner & Jensen (1997) found that the European *M.suspectus* was only found in Eurasian

firs and in one Asian fir, but not in North American species. In contrast, the Holarctic *M.specularis* colonised both Eurasian, North American and Asian firs.

Thus in general seed insects have much lower chances of introduction than ordinary herbivorous insects. The perfect scenario would be forest nurseries situated in a very diverse forest of introduced and indigenous tree species or close to arboretums with a multiple number of specimens of each tree species. In a French arboretum, Da Ros *et al.* (1993) described the potential for native seed insects to shift to exotic species. Our results show that for at least two new Danish seed chalcids the few known records are from such localities. Thus from a phytosanitary viewpoint arboretums should be observed for the detection of introduced seed insects.

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