Eur. J. Entomol. **97**: 419–426, 2000
ISSN 1210-5759

African-Arabian and Asian-Pacific "*Mocis frugalis*": Two distinct species (Lepidoptera: Noctuidae)

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Key words. Noctuidae, *Mocis frugalis*, *Mocis proverai*, new species, pest Lepidoptera

Abstract. It is shown that under the name *Mocis frugalis* (F., 1775), considered to represent a widespread pest of graminaceous crops in the Eastern hemisphere and the Pacific, two species have been hitherto confused. Populations from Africa and Arabian Peninsula are described as *Mocis proverai* sp. n. The main characters which distinguish the African-Arabian *M. proverai* from *M. frugalis* of Asia and the Pacific are found in the genitalia, especially the configuration of the male vesica and female bursa copulatrix.

INTRODUCTION

According to Poole (1989) nearly forty species are currently recognised within the genus *Mocis* Hübner, 1823 (= *Remigia* Guenée, 1852) of the noctuid subfamily Catocalinae. They mostly occur in tropical and subtropical regions of the World and include some well-known grass feeders of economic importance, e.g. *Mocis latipes* (Guenée, 1852), *M. repanda* (F., 1794) and *M. frugalis* (F., 1775) (Gallego, 1946; Margheritis & Rizzo, 1965; Zhang, 1994).

An intriguing phenomenon occurring in *Mocis* and other groups of the Catocalinae is the sharing of an extraordinarily similar habitus between species that conversely are well distinct genitalically. This often led early authors, who traditionally relied upon the external habitus for species identification, to treat different taxa as visually identical units (e.g. Warren, 1909–1914; Hampson, 1913). Credit should be given to Berio (1953, 1954, 1955, 1956) for having recognised several species pairs in the Catocalinae, including *Mocis undata* (F., 1775) / *M. mayeri* (Boisduval, 1833) and *M. repanda* (F., 1794) / *M. conveniens* (Walker, 1858), respectively Asian / African and American / African, which were eventually diagnosed because of outstanding differences in the male genitalia.

One of the nominal taxa that withstood Berio's attempts of splitting widely distributed species into at least one vicariant per continent is *Mocis frugalis* (F., 1775), known as a major pest of sugar cane, pasture grasses, oats, rice and other graminaceous crops in the Old World and Australian region (Fletcher, 1917; Holloway et al., 1987; Common, 1990; Zhang, 1994; Wojtusiak, 1996). The species was in fact recorded from almost the whole of Africa, the Middle East, eastern Palaearctic, and Indo-Australian region (Hampson, 1913; Robinson, 1975; Commonwealth Institute of Entomology, 1976; Hacker, 1990; Wiltshire, 1990; Zhang, 1994; Wojtusiak, 1996). Nevertheless, a deeper look into the morphology of examples from several areas throughout this range showed them to represent two species, apparently with African-Arabian and Asian-Pacific distributions respectively. The name *M. frugalis* applies to the oriental species, while the African-Arabian species deserves formal description, as there is not an available name in synonymy (cf. Poole, 1989):

Noctua frugalis F., 1775 (type loc.: India).
Mocis fragalis; Barnett, Emms & Holloway, 1999, incorrect subsequent spelling.
Chalciope lycopodia Geyer, 1837 (type loc.: Java).
Chalciope lycophotia; Berio, 1965, incorrect subsequent spelling.
Remigia translata Walker, 1865 (type loc.: Ceylon).

Infrasubspecific names (unavailable nomenclaturally):

Remigia frugalis ab. *nigripunctata* Warren, 1913.
Remigia frugalis f. *nigropunctata*; Berio, 1965, incorrect subsequent spelling.
Mocis frugalis ab. *frugalisana* Strand, 1916.
Mocis frugalis ab. *frugalisans*; Berio, 1965, unjustified emendation.

As Wiltshire (1964) used "*Mocis frugalis* F. subsp. *nigripunctata* Warren" while recording specimens from Bahrain which, during the course of this study, have revealed to belong to the new species, a question apparently arises as to whether or not Wiltshire's (1964) citation made available the name *nigripunctata*, particularly when considering that Hacker (1999) listed "*nigripunctata* Wiltshire, 1964" in the synonymy of *M. frugalis* in a catalogue of Arabian Lepidoptera. This circumstance is regulated by article 45.5.1. of the International Code of Zoological Nomenclature (International Commission on Zoological Nomenclature, 1999). According to this article, Wiltshire (1964) would have made available and taken authorship of *nigripunctata* only in case the name had fulfilled the requirements of articles 11–18, but it clearly contravenes those of article 13.1. The name *nigripunctata* with authorship assigned to E.P. Wiltshire thence does not enter into zoological nomenclature. Going through Wiltshire's (1964) paper it is evident that use of the term "subspecies" had been followed as a routine and without the intent to differentiate any population of *Mocis*. On the contrary, Wiltshire's (1990) statement

that "in habitus (*Mocis frugalis*) is variable but the various forms have no geographical significance" would not have been published without a prior synonymisation of *nigripunctata.*

MATERIAL AND METHODS

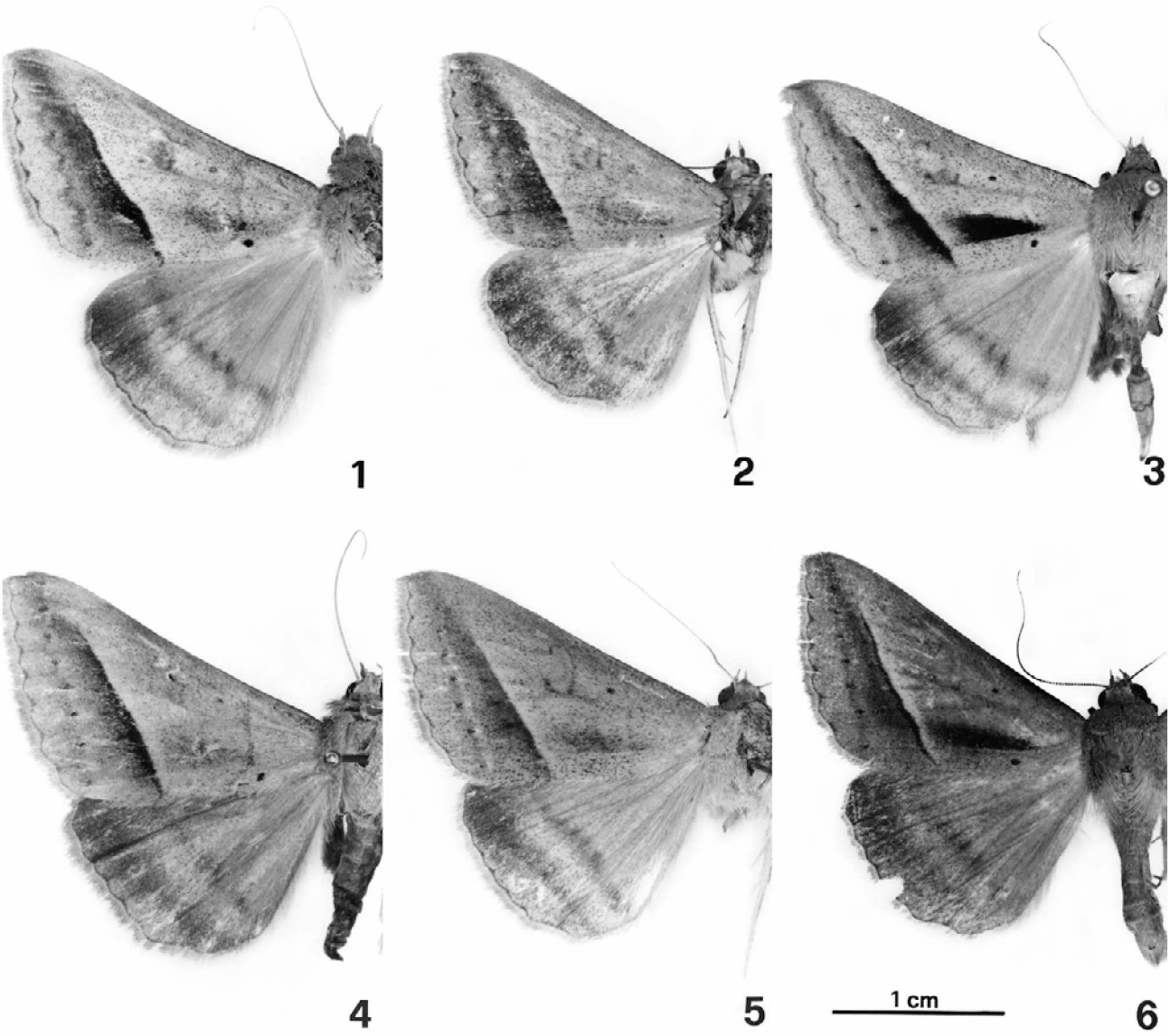
Male and female specimens corresponding to the old concept of *Mocis frugalis* from the Ivory Coast, Upper Volta, Ghana, Cameroon, Congo, Sudan, Kenya, Tanzania, Madagascar, Bahrain, Yemen, Ceylon, Afghanistan, China, Vietnam, Malaya, Borneo, Bali, and New Guinea, were dissected according to the standard procedures for genitalia preparations (e.g. Hardwick, 1950; Reid, 1983). As diagnostic features of major importance are often found in the vesica (= endophallus) (cf. Hardwick, 1950; Lafontaine, 1987; Mikkola, 1992) particular emphasis was given to the study of its configuration. Vesicae were everted by cutting the ductus ejaculatorius at its junction with the aedeagus with sharp microsurgical scissors; distilled water was then pumped into the aedeagus with a hypodermic syringe while immersed in distilled water, aedeagus and needle being held with a pair of fine forceps. Staining was carried out in a 1% mercurochrome solution for 15 h. Aedeagi were then soaked in ethanol (95%) to stop staining and harden the inflated vesicae. To allow comparisons between specimens drawings were made using a camera lucida attached to a Wild M5 stereoscopic microscope. In order not to alter the shape of vesicae, aedeagi were first grafted onto micropins pinned to cubes of cork and drawn while immersed in ethanol. Permanent slides were eventually prepared by mounting the genitalic parts in Euparal. A lettering was arbitrarily assigned to vesical swellings in order to unambiguously identify the lobes of the endophallus.

DESCRIPTION OF THE NEW SPECIES

Mocis proverai sp. n.

Mocis frugalis sensu auctorum (African-Arabian records)

Diagnosis. Habitus virtually indistinguishable from *Mocis frugalis* (F., 1775), showing similar phenotypic



Figs 1–6: Habitus of *Mocis*. 1–3: *Mocis proverai* sp. n. 1 – Ghana, Aburi, ♂ (holotype); 2 – Aburi, ♀ (paratype); 3 – Kenia, Mombasa, ♂. 4–6: *Mocis frugalis* F. 4 – China, Szechwan, ♂; 5 – Vietnam, Tam Dao, ♀. 6 – Sabah, Mt. Alab, ♀.

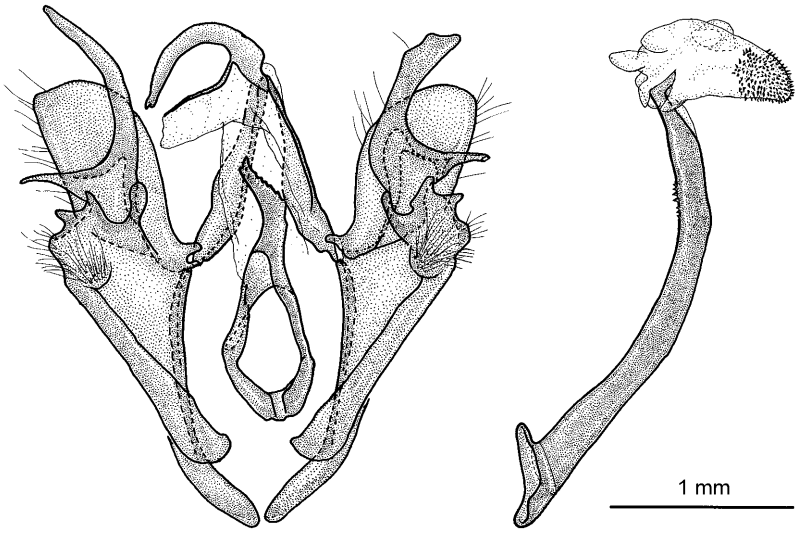


Fig. 7. *Mocis proverai* sp. n., male genitalia (holotype).

variation, consisting of three main morphs and intermediates (cf. Strand, 1916; Gaede, 1935–1937; Berio, 1965) (Figs 1–6). At most, the background coloration of *M. proverai* is often lighter, particularly in the distal half of the medial field of the forewing, thus producing a more contrasting pattern in the forms with dark markings. Both species are very variable in the genitalia structure, but some traits are constantly different and hold diagnostic value for *M. proverai*. In the male, the superior and inferior processes of the left clasper are unequal, the superior being usually more than twice as long as the inferior, hence conferring a pronounced asymmetry to the whole apparatus (in *M. frugalis* the processes are of comparable length and the valvae approximately symmetrical) (Fig. 8). The left ampulla is longer and the stout superior process of periphallus is more sinuous, with the outer border (the smooth one) showing two points of inflection (i.e., "S"-shaped) and a distinct small (rarely two-three) preapical spine on the second flex, while in *M. frugalis* the border is more evenly curved and the spine is missing (Fig. 9). The inflated vesica of *M. proverai* is less markedly bent toward aedeagal tube than in *M. frugalis*, lobe *a* being approximately twice as broad and lobe *b* bearing usually a finely spinulose field at apex, always absent in *M. frugalis* (Fig. 10). In *M. proverai* a large bag-like swelling *c*, absent in *M. frugalis*, protrudes dorso-laterally from the main body of the vesica and is linked to a saccular heterolateral lobe *d*; this configuration determines a mesial constriction which does not occur in *M. frugalis*. In the latter species, lobe *d* is very long, distally tapering, and projecting downward; moreover, it is inserted in a so lowered position that it might be even questioned whether it is homologous with that in *M. proverai*. Lobes *e* and *f* of *M. proverai* are well distinct and laterally positioned, while in *M. frugalis* they form a largely united ventrally positioned body. Proximad to *e* and *f* there is a sclerite, broad and weakly sclerotized in *M. proverai*, small and intensely pigmented in *M. frugalis*. Last but not least, the distal lobes *g*, which are more slender in *M. frugalis*, bear totally different vestiture of spines; in *M. proverai* this consists of dense minute spiculae, whereas in *M. frugalis* the vestiture has more sparse long spines (differences in spinosity can be easily observed through the aedeagal wall without everting the vesica). The extent to which the shape of the superior process of the right clasper can vary is much greater in *M. proverai*.

In the female genitalia, the appendix bursae of *M. proverai* is weakly sclerotized and poorly defined, consisting of some posterolateral ribs lying on the flank of corpus like a pouch, but practically becoming part of the corpus when this is fully extended; in contrast, the appendix bursae of *M. frugalis* is deeply sclerotized and well separate from the corpus, arising perpendicularly from it (Fig. 11).

Description

Male. Length of forewing 18–21 mm. Upperside facies as illustrated (Figs 1–3). Antenna filiform, light yellowish brown; head, thorax, legs and abdomen beige. Forewing light beige, with sparse brown scales, particularly along costa and above vein 1A+2A; elements of pattern dark brown; postmedial defined internally by pale yellowish beige. Variability occurs as to degree of straightness of postmedial, more or less pronounced, dimension of subbasal dot, which may also be absent, and intensity of dark pigmentation of background and any of all pattern elements, most conspicuous phenotypes showing net transverse mesial patch above 1A+2A. Hindwing light beige with sparse brown scales, basally suffused by brown; postmedial and subterminal fascia greyish brown; tornal area beyond subterminal generally light. Underside beige with ochreous hue and diffuse grey markings consisting of patch at end of cell, postmedial, and wide postdiscal fascia at forewing, postmedial and subterminal fascia at hindwing, where small grey discal dot may also occur.

Male genitalia as illustrated (Fig. 7). Variability occurs as to both absolute and relative lengths and configuration of valval processes, and shape of periphallus (Figs 8–9). Vesical lobes can vary as to their relative sizes, but their topological relationships remain unaltered (Fig. 10).

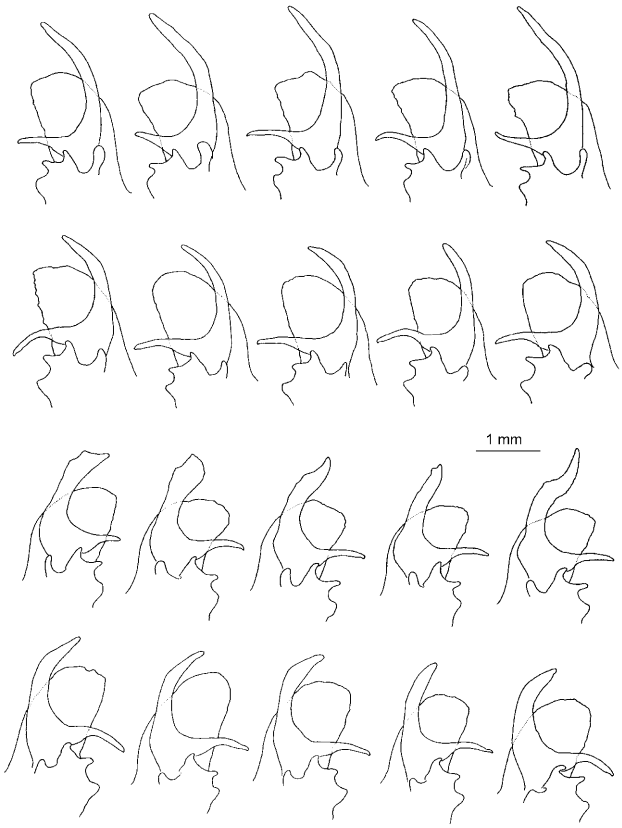


Fig. 8. Apices of left (rows 1–2) and right valvae (rows 3–4) of *Mocis*. *M. proverai* sp. n. (rows 1, 3): Ghana, Aburi (holotype); Accra (paratype); idem (paratype); idem (paratype); Congo, Brazzaville. *M. frugalis* F. (rows 2, 4): Ceylon, Bentota; Malaya, Genting Highlands; idem; Cameron Highlands; Borneo, Kundasang.

Female (Fig. 2). Length of forewing 18–21 mm. Phenotypic patterns corresponding to those of males, although relative frequencies are different (cf. Berio, 1965), i.e., with basal and median fields of forewing uniformly coloured (common in this sex), with a dark brown transverse suffusion in median field above 1A+2A (rare in the females), and bearing a dark dot above inner margin below 1A+2A before antemedial.

Genitalia as illustrated (Fig. 11).

Type material. Holotype ♂, Ghana, Aburi, vi.1984 (genitalia slide no. 618, A. Zilli praep.), ex coll. P. Butti, in Museo Civico di Zoologia, Roma. Paratypes: Ghana, Aburi, xi.1984, 1♀; Accra, vii.1983, 1♂, 3♀; ix.1983, 1♂; (without date) 1♂; all ex coll. P. Butti, in Museo Civico di Zoologia, Roma; Ghana, Kumasi, 19.xi.1965, 1♀; 20.xi.1965, 1♀; S. Endrodi-Younga leg.; Kumasi-Kwadaso, 300 m, iv.1970, 1♂; v.1970, 1♀; D. Schröder leg., all in Zoologische Staatssammlung München.

Additional material examined. Cameroon, Douala-Japoma, i.1983, 1♀; Congo, Brazzaville, iii.1982, 1♂; both ex coll. P. Butti, in Museo Civico di Zoologia, Roma; Ivory Coast, Abidjan, 3.–20.xi.1952, 3♀, L. Sheljuzhko leg.; Upper Volta, Bobo, 17.ix.1976, 1♀, H. Politzar leg.; Nigeria, Kaduna, 10.vii.–6.viii.1970, 4♂, 5♀; 28.ix.1970, 1♀; 20.xi.1970, 1♀; 26.i.1971, 1♀; 8.vii.1971, 1♀; 18.–23.x.1971, 2♂; H. Politzar leg.; Sudan, Ed Damer, Hudeiba, 28.ii.–4.iii.1962, 3♂, 2♀, R. Remane leg.; Kenya, Mombasa, 5.vii.1952, 1♂, Lindemann & Pavlitzki leg.; Tanzania, Urunguru Mts, 1♂, 26.xii.1961, G. Heinrich leg.; Madagascar, 1♀, leg. Melon; all in Zoologische Staatssammlung München; Saudi Arabia, Hejaz, Bahrein Oasis, 29.i.1948, 1♂; Wadi Yemeniya, 29.i.1948, 1♀; Bahrain, "gardens", 22.i.1960 2♂; 7.iii.1960, 3♂; 27.iii.1960, 2♂, 1♀; 17.iv.1960, 1♀; 29.xii.1960, 2♂; all E.P. Wiltshire leg., in Natural History Museum, London; Yemen, Prov. Abyan, 13°09′69″N, 45°19′46″E, 1♀, A. Bischof, J. Bittermann, M. Fibiger, H. Hacker, H. Peks & H.-P. Schreier leg., in coll. A. Bischof, M. Fibiger, H. Hacker & H.-P. Schreier.

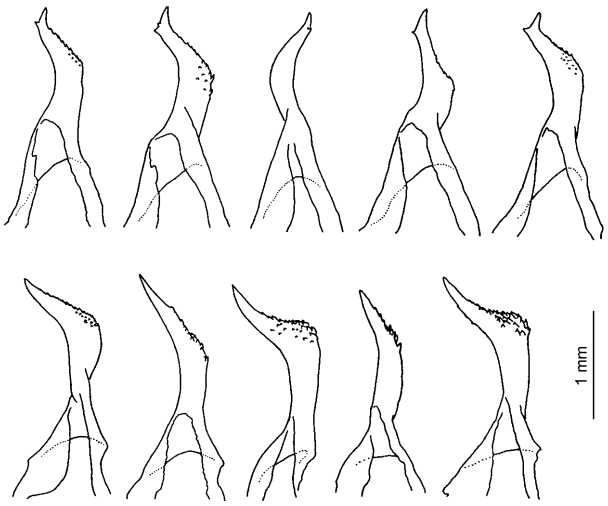


Fig. 9. Superior processes of periphallus of *Mocis*. *M. proverai* sp. n. (1st row): Ghana, Aburi (holotype); Accra (paratype); idem (paratype); idem (paratype); Congo, Brazzaville. *M. frugalis* F. (2nd row): Ceylon, Bentota; Malaya, Genting Highlands; idem; Cameron Highlands; Borneo, Kundasang.

Etymology. The species is named after Piero Provera (Rome) in recognition of his extensive activity in lepidopterology.

Distribution. Africa: Ivory Coast, Upper Volta, Ghana, Nigeria, Cameroon, Congo, Sudan, Kenya, Tanzania, Madagascar, and Zaire (cf. Berio, 1965: 279); Arabian Peninsula: Saudi Arabia, Yemen, Bahrain.

COMMENTS

Hitherto *Mocis frugalis* (F.) has been known as a widely distributed species occurring in the Eastern hemisphere and the Pacific, recorded from the Cape Verde Is., Ivory Coast, Ghana, Nigeria, Niger, São Tomé, Congo, Zaire, Sudan, Egypt, Somaliland, Kenya, Zambia, Malawi, Mozambique, Zimbabwe, South Africa, Madagascar, Comoro Is., Mauritius, Seychelles, Saudi Arabia, Yemen, Bahrain, Oman, Chagos Is., Pakistan, India, Ceylon, Nepal, Sikkim, Bangladesh, Burma, Andamans, Nicobars, Thailand, Laos, Cambodia, Vietnam, China, Amur basin, Loo-choo I., Taiwan, Ogasawara Is., Japan, Philippines, Malaya, Singapore, Sarawak, Sabah, Indonesia (Sumatra, Kalimantan, Java, Bali, etc.), Cocos-Keeling Is., Australia (Western Australia, Northern Territory, Queensland, New South Wales), New Guinea, Solomons, Caroline Is., Marshall Is., New Hebrides, New Caledonia, Loyalty Is., Fiji, Ellice Is., Gilbert Is., Norfolk I., Kermadecs, Tonga, Friendly Is., Samoa, Cooks, Rapa I., Society Is., Tuamotu Is., and Marquesas (Hampson, 1913; Warren, 1913; Holland, 1920; Rothschild, 1921;

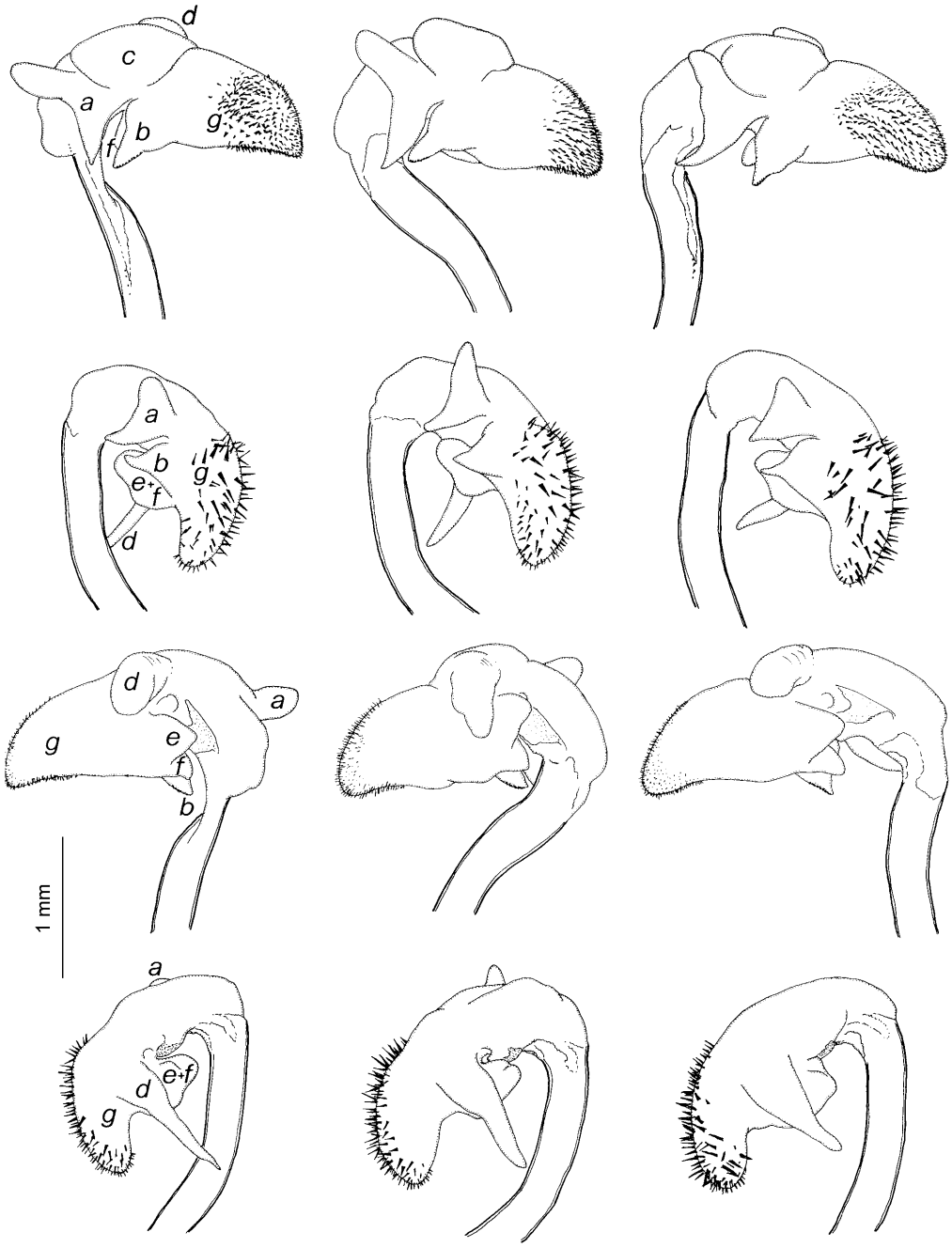


Fig. 10. Everted vesicae of *Mocis* in left hand (rows 1–2) and right hand views (rows 3–4) (lettering indicates vesical lobes). *M. proverai* sp. n. (rows 1, 3): Ghana, Aburi (holotype); Accra (paratype); Congo, Brazzaville. *M. frugalis* F. (rows 2, 4): Ceylon, Bentota; Bali, Sanur; Borneo, Kundasang.

Wiltshire, 1952, 1962, 1964, 1985, 1990; Berio, 1965; Legrand, 1965; Laporte & Vuattoux, 1975; Robinson, 1975; Holloway, 1977; Common, 1990; Hacker, 1990; Haruta, 1993; Zhang, 1994; Wojtusiak, 1996; Barnett et al., 1999; Yanagita & Nakajima, 1999). The new species *M. proverai* has so far been confirmed from the Ivory Coast, Upper Volta, Ghana, Nigeria, Cameroon, Congo, Zaire, Sudan, Kenya, Tanzania, Madagascar, Saudi Arabia, Yemen, and Bahrain, and there is strong evidence that all the African and Arabian records of *M. frugalis* must be referred to *M. proverai*, which would thus represent a discrete African-Arabian vicariant of *M. frugalis*. Further studies are however required for defining the actual ranges of the two species and to ascertain whether or not they overlap in some areas of the Middle East and the Indian Ocean islands, although there seems to exist a geographic disjunction between the two species from Saudi Arabia to Afghanistan.

In addition to the external similarity between the two species, the fact that they also share the same basic colour polymorphism undoubtedly represents an unusual circumstance. This phenomenon is commonly observed in vicariant species pairs, at least within the Noctuidae, and may be put in relation to speciation events subsequent to

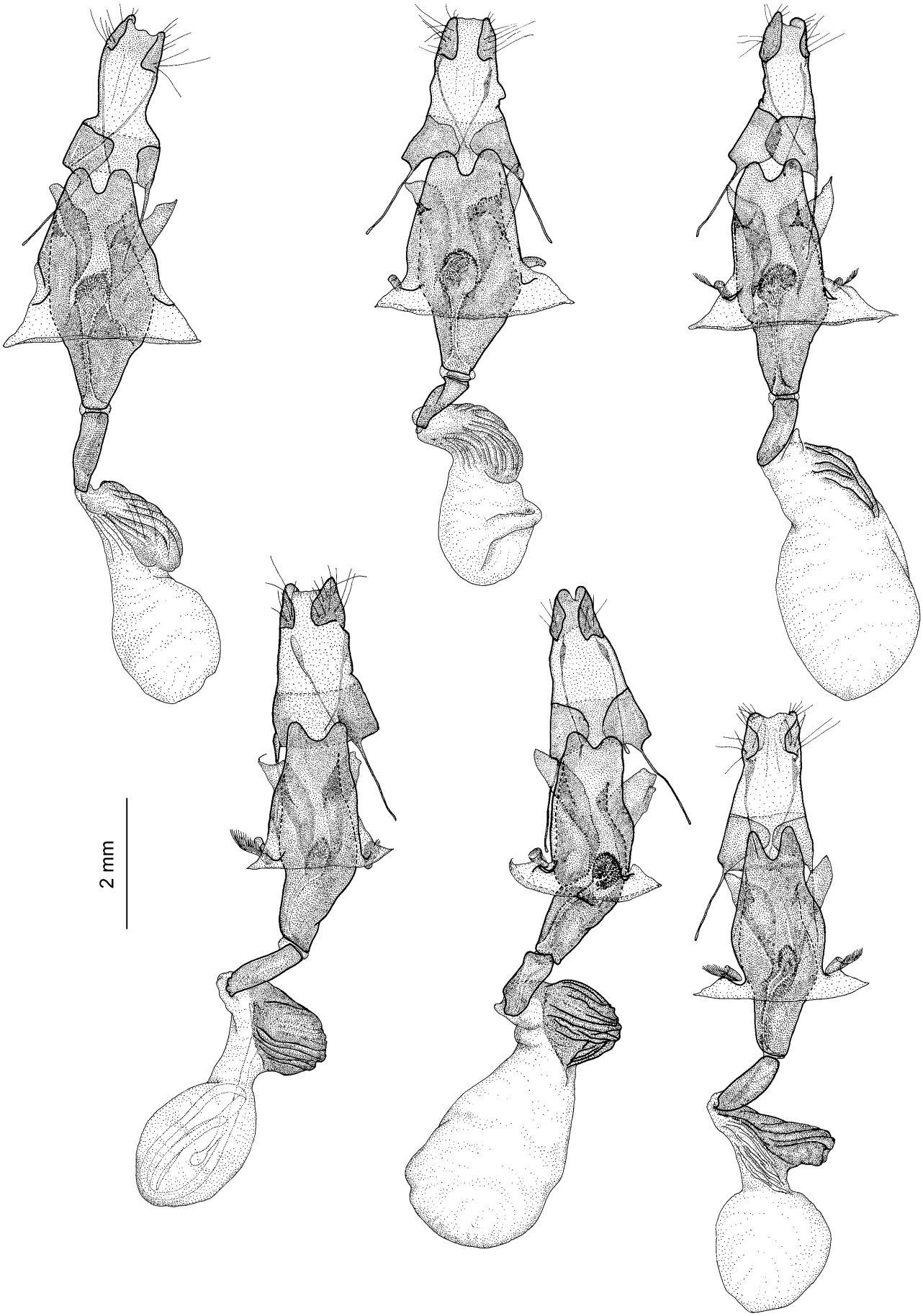


Fig. 11. Female genitalia of *Mocis*. *M. proverai* sp. n. (1st row): Ghana, Accra (paratype); Aburi (paratype); Cameroon, Douala-Japoma. *M. frugalis* F. (2nd row): Ceylon, Bentota; Borneo, Kundasang; Vietnam, Tam Dao.

the acquisition of the genetic variation by the common ancestor. Point of major interest would be the elucidation of the reasons for a much greater variability of male genital structures in the African-Arabian taxon. Some traits are presumably subject to geographical variation, e.g. the superior process of the left clasper is seemingly shorter in East African material, the preapical spine on the outer border of periphallus is much reduced in specimens from Bahrain, and almost any structure of a specimen from Sudan appears as more slender, but it is an intrapopulational variability of features like the right clasper that has no correspondence in *M. frugalis*. Whether this situation reflects different levels of genetic variation in the two species or a greater developmental stability in *M. frugalis* is a matter of speculation.

ACKNOWLEDGEMENTS. The author wishes to express his most sincere thanks to A. Hausmann (Zoologische Staatssammlung München) and M. Honey (The Natural History Museum, London) for allowing the examination of the material under their care, H. Hacker (Staffelstein) for loan of specimens, E. Colonnelli (Rome) for valuable discussion on nomenclatural aspects, D. Van Assum, G. Tweehuysen and W. Hogenes (Amsterdam) for their generous help in tracing literature, and also two referees for helpful suggestions. This research was in part financially supported by a grant from the MURST (Geographic variation and diversity at the levels of species, fauna and animal community: historical and ecological factors).

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Received July 9, 1999; accepted September 24, 1999