

THE GUATEMALAN POTATO TUBER MOTH (*SCROBIPALPOPSIS SOLANIVORA* POVOLNÝ, 1973) BEFORE THE GATEWAYS OF EUROPE (LEPIDOPTERA, GELECHIIDAE)

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Abstract

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After its spread through many potato growing states of South America the Guatemalan potato tuber moth (*Scrobipalopsis solanivora* Povolný, 1973) was introduced into the Canary Islands (1998 – 2000) and caused several outbreaks both in potato fields and stores. This paper deals with the generic status of this insect pest and summarizes the most important results of its studies and research. This paper is aimed mainly at the European institutions of plant protection reacting especially on the needs expressed by the European Plant Production Organisation (EPPO). The paper is accompanied by coloured figures of moths and damage on potato tubers and with sketches of taxonomically important characters of the pest.

Guatemalan potato tuber moth, potato pest, biology, dispersal, control measures, South America, Canary Islands

The economic importance of *Scrobipalopsis solanivora* Povolný, 1973 (Figs. 1, 3, 5, 6, 7, 8) was first recognized in Costa Rica at the time, when the material of moths and caterpillars was first sent to me for identification (Povolný, 1973). This serious insect pest of potato became the object of several theses (e.g. Barroso, 1974; Casados, 1984; Torres, 1989) dealing with different aspects of its life history (e.g. Gamboa & Notz, 1990; Murillo, 1981; Ocuñaga & Ochoa, 1987; Salazar & Escalante, 1984; Inoue et al., 1994; Salas, 1987; Torres et al., 1997; PRECODEPA, 1989, 1998). The aim of this paper is to summarize the most important data of its taxonomy, life-cycle, distribution, economic importance etc. accompanied, at the same time, by adequate illustrations (still very insufficient in above literature).

Scrobipalopsis solanivora Povolný, 1973

Taxonomy

Although the Guatemalan potato tuber moth was described unambiguously its description being accompanied by necessary informations, a confusion arose concerning its generic status. This situation starts with the paper by Hodges & Becker (1990) who synonymized the genus *Scrobipalopsis* Povolný, 1967 (and several other neotropical gnorimoschemine genera) with the genus *Tecia* Strand, 1910 (attributing this name to Kieffer & Jörgensen, 1910). I opposed this synonymization two years later (Povolný, 1993), but this study remained unknown to later students of *Scrobipalopsis solanivora*. I therefore repeat and resume this my argumentation which is mainly based on the morphology of the genitalia, on ecology (so far known) and partly on geographic distribution. There

is, however, no doubt that the two genera – *Scrobipalopsis* and *Tecia* are more or less closely related belonging to the so-called scrobipalpoid branch of the tribe (Povolný, 1967, 2002). Both are essentially American, but *Scrobipalopsis* is represented also in the European Alps (*Scrobipalopsis petasitis* Pfaffenzeller, 1867). The Nearctic *Scrobipalopsis* is represented by some 8 species located essentially in the Californian and in the neighbouring distributional eremic centres, viz. Taxoeremic, Gilaeremic, Salsoeremic. They are leaf-miners of Asteraceae (especially of the tribe Heliantheae). Their male genitalia show prolongate paired processes, the parabasal one showing the trend towards fusion with the base of the sacculus process. Uncus is broadly rounded and arched, bare or with very delicate marginal hairs. Gnathos spine is distinct but comparatively small with a tendency towards reduction [in *Scrobipalopsis tetradymiella* (Busck, 1903)]. The valva is stiff, comparatively long and slender, and only moderately dilated apically or without apical dilatation. Aedeagus is comparatively long, caecum distinctly shorter than slender elongate corpus aedeagi (Figs. 1, 3).

The genus *Tecia* comprises, so far known, some 4 – 5 purely Neotropical (Argentinian and Bolivian) species producing galls in shrub-like Solanaceae (especially species of the genus *Baccharis*). The male genitalia tend towards an acute (not rounded) tip of uncus, slender elongate gnathos. The paired processes are short with truncate, obtuse tips, valva is short, moderately curved or sigmoid with dilated tip; aedeagus comparatively short, its trunk is not essentially slenderer and longer than caecum (Fig. 2).

Generally, the male genitalia of *Scrobipalopsis* and *Tecia* are, however, rather similar. The situation of the female genitalia in the two genera is rather different. The subgenital plates of *Scrobipalopsis* tend to form a basal dilatation of anterior apophyses or these show a process. The subgenital plates in *Scrobipalopsis* are elongate rather than broad, sometimes very long, in *Tecia* same long as broad (subquadrate) or broader than long. Both genera show a trend towards the reduction of signum bursae this tendency being distinctly stronger in *Tecia* than in *Scrobipalopsis*. The form of the female genitalia indicates two different functional adaptations: More or less „superficial“ oviposition in *Tecia* and „deeper“ oviposition in *Scrobipalopsis* obviously when inserting the eggs into crevices etc. Purely habitually, the species *Tecia venosa* (Butler, 1883) has a unique labial palpus showing extremely elongate second segment with a long tuft of hairs possibly increasing the scent attraction (Fig. 5).

It should also be emphasized that at least some species of *Scrobipalopsis* show partly striking sexual dichroism: The female of *Scrobipalopsis petasitis* has rather striking whitish ground coloration of the

forewing, whereas the male has a grey cinereous forewing. *Scrobipalopsis solanivora* shows not only distinctive sexual dichroism, but the male is usually smaller (figs. in coloured plates). In *Tecia* no striking sexual dichroism was observed so far, but this fact should be corroborated by additional material of these moths.

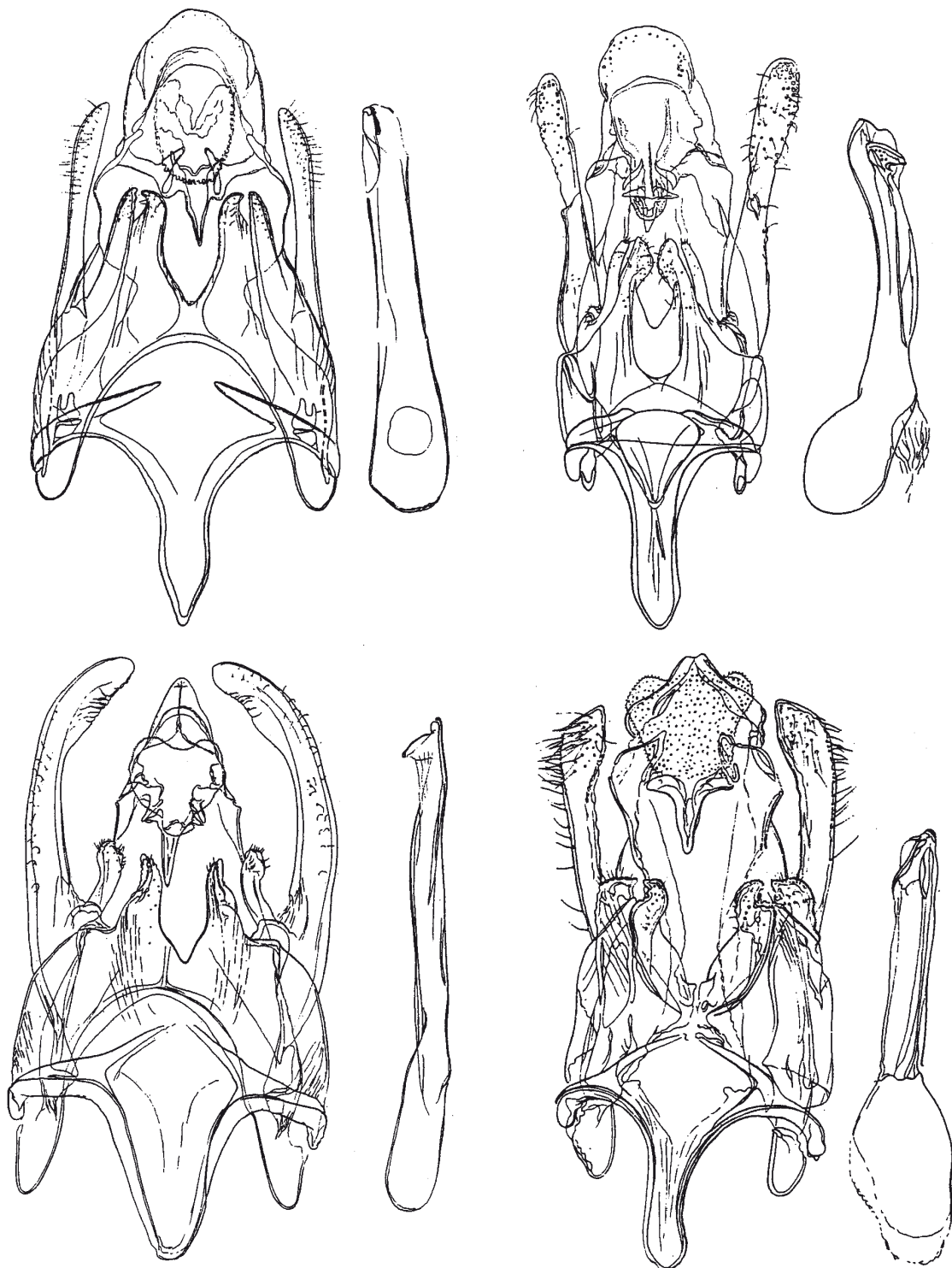
The two genera show common trends also in the forewing pattern: This is essentially radiate with two or three central blackish stigmata which are occasionally absent. Some species of *Scrobipalopsis* are whitish and with poorly developed dark stigmata (Fig. 5).

The taxonomic relations between *Scrobipalopsis* and *Tecia* are also complicated by the fact that only *Scrobipalopsis solanivora* is a „common“ species, all other taxa of these two genera being thoroughly rare or very rare, and in some of them only one sex is known.

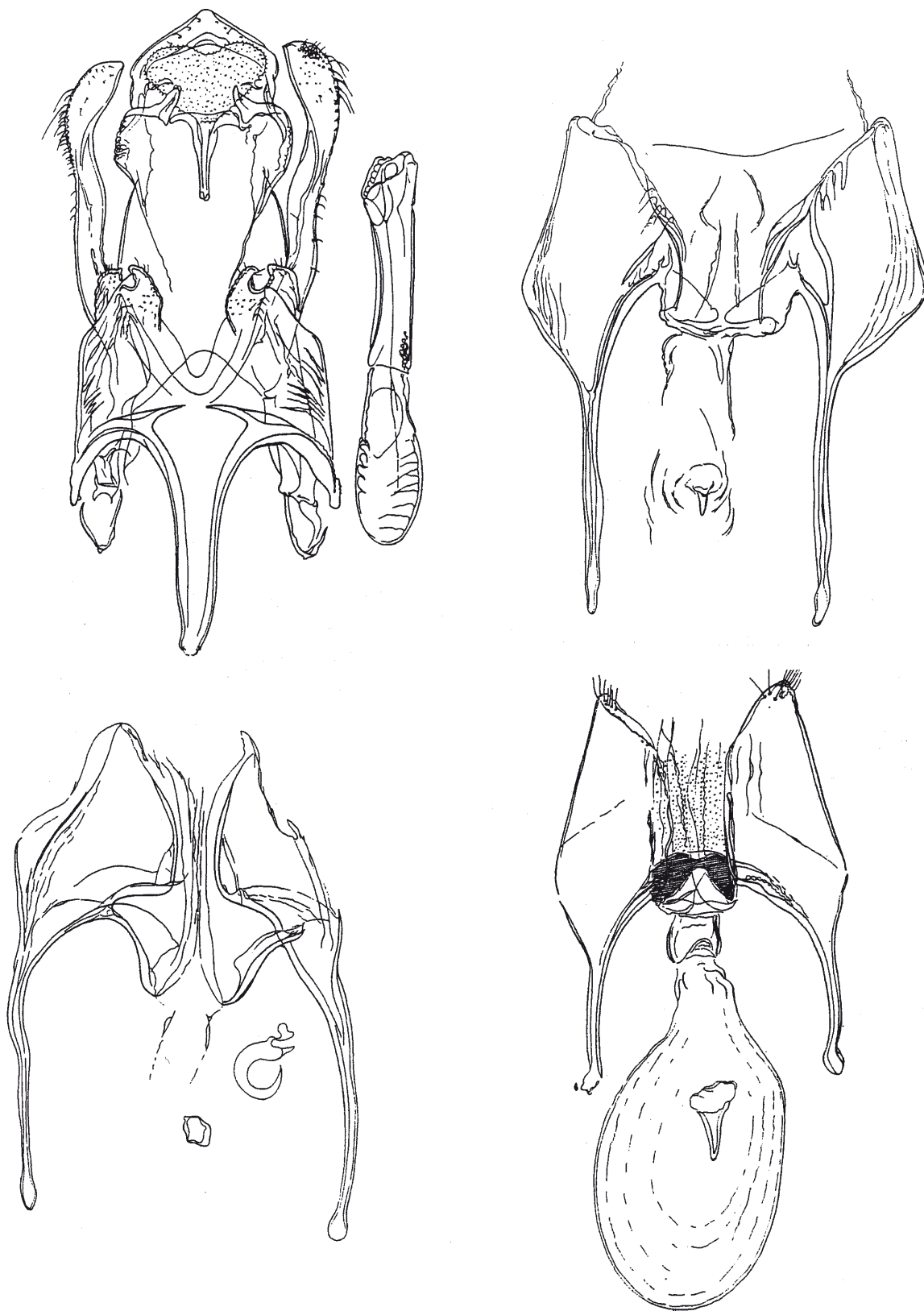
The taxonomic position of *Scrobipalopsis solanivora* shows one character „intermediate“ between the genera *Tecia* and *Scrobipalopsis* (which represent more or less two evolutionary trends rather than discrete generic taxa): Its uncus is „tipped“ rather than rounded (like in *Scrobipalopsis*), but all other genitalic structures, especially the structure of the female genitalia are like in other trends within *Scrobipalopsis* (Figs. 1, 2).

Biology

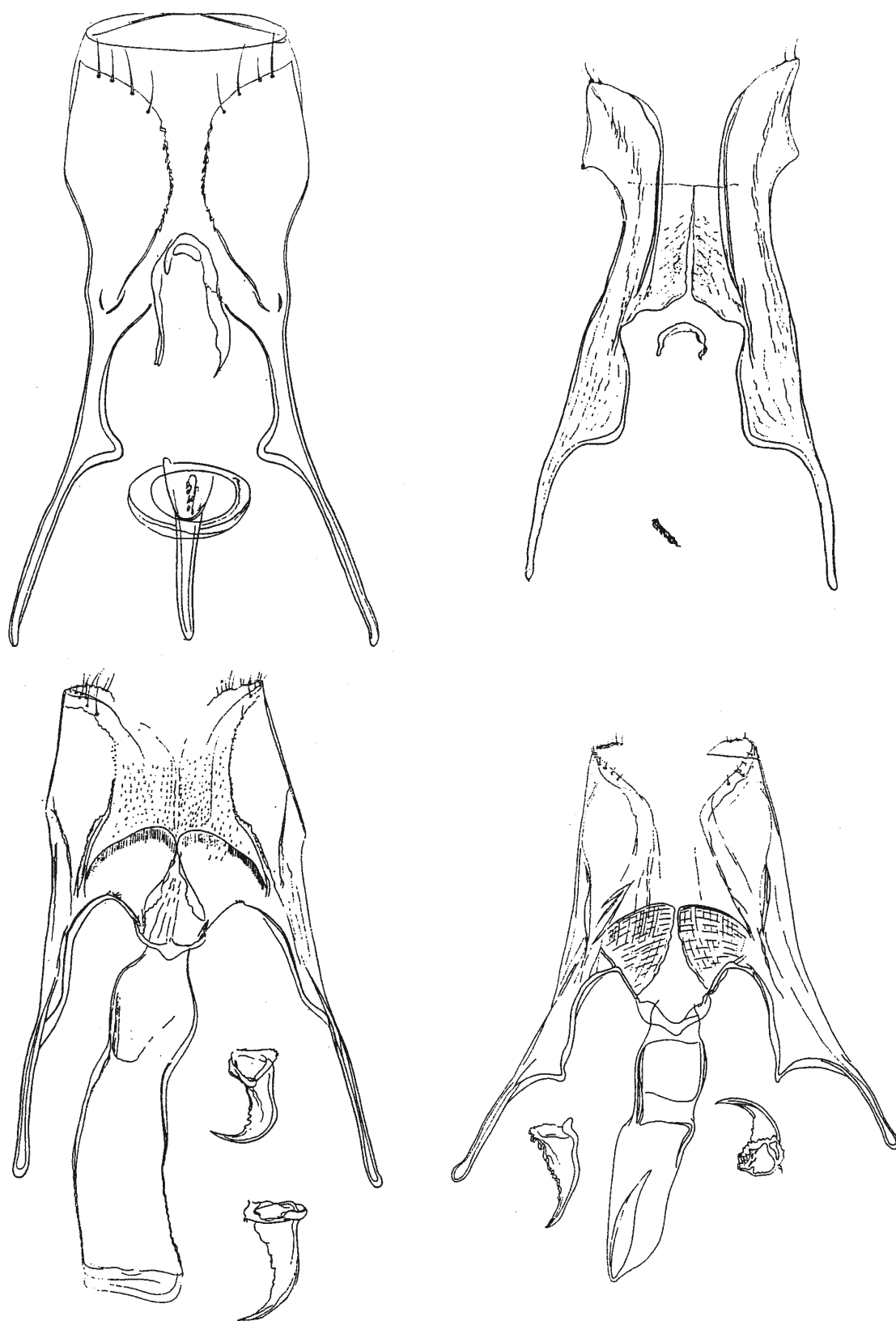
The adults (moths) are rather active but short distance dusk and nocturnal fliers and they occur primarily in potato cultures of all kinds (seed and ware potatoes, farmer-produced potatoes etc). The females lay eggs on soil surface or on protruding or uncovered potato tubers, less often (or during overpopulation) on stems and leaves. The optimum laboratory temperature is 15 °C, during which the females may lay up to 50 eggs daily, a total up to 490 eggs during nearly two months. The developmental threshold was 9 °C at larval instars (Notz, 1995). The emerging caterpillars bore into the tuber producing galleries which may completely destroy the tubers. The attacked tubers also decay due to the activity of the bacterial microflora (secondary rotting). After completing their development the fourth instar caterpillars leave the tubers through a minor circular exit hole (of 2 – 3 mm), produce a cocoon with silk walls covered by minute particles of soil, dry detritus etc. The cocoons are situated on soil surface, but also on bags with infested tubers on walls of stores etc. Under laboratory conditions, with mean temperatures of 20 °C, the caterpillars hatched after 6 – 7 days, the development of caterpillars lasted 14 days in average and the pupal stage next 15 days. The influence of the temperature on the development of *Scrobipalopsis solanivora* was studied by Notz (1995). His results showed that the species develops 2 generations yearly



1: Male genitalia of: *Scrobipalopsis petasitis* (top left); *Scrobipalopsis tetradymiella* (top right); *Scrobipalopsis solanivora* (bottom left); *Tecia venosa* (bottom right)



2: Male genitalia of *Tecia confirmans* (top left); Female genitalia of: *Tecia venosa* slightly compressed (top right); *Tecia albinervella* slightly compressed (bottom left); *Tecia venosa* (normal preparation) (bottom right)



3: Female genitalia of *Scrobipalopsis*: *Scrobipalopsis petasitis* (top left); *Scrobipalopsis petrella* (top right, signum strongly reduced); *Scrobipalopsis solanivora* (bottom left and right- without and with slight pressure to see the characteristic dilatation near anterior apophyses base)

at 10 °C and gradually up to 10 generations yearly at 25 °C. At constant temperatures of 30 °C the larval mortality amounted 100%. Correspondingly to these results the greatest infestations in potato cultures vary between 1.300 m a.s.l. in Costa Rica (with annual temperature range between 19 °C to 23 °C), whereas in Ecuador (its North with most heavily infested area) the potato growing area is situated between 2000 m a.s.l. up to 3000 m a.s.l. and in Venezuela in three zones between 500 m a.s.l. up to 3.500 m a.s.l. At higher altitudes the species suffers especially from increased precipitations. According to Torres et al. (1997), the optimum development temperature is 25 °C during which one generation develops within about 42 days. This suits well with the results of Notz (1995) and with the fact that in stored potato tubers accessible to the ovipositing moths the generations followed within each 4 – 5 week intervals. After its introduction to the Canary Islands (possibly with illegally imported potatoes e. g. from Venezuela, Colombia or Ecuador) severe outbreaks of *S. solanivora* were observed in June 1999 (EMPPO, 2003). Starting with the summer of 2000 the pheromone traps were installed both in fields and in stores with the result that in February 2001 only three of 21 sites studied remained free from the moths, but up to 15 – 20 males were captured in several stores during one week.

Generally, the moth shows a high environmental adaptability (developing both in fields and in stores) especially under the subtropical conditions. Whereas it appears to be a mountainous pest in Central and mainly in South America, especially in the zones between 2000 – 3000 m.a.s.l., the highest damage in the Canarian Islands was observed at 500 m – 600 m a.s.l. This last important fact should be taken into special consideration in connection with the possible introduction of this pest into the potato growing areas in Africa and Europe.

Kinds of dispersal

Two kinds of spread of the potato tuber moth seem to exist: 1) Purely local dispersal due to flying moths may infect fields and stores. 2) It is obvious that the rapid spread of the moth in Central and South America followed by such commodities as potato plants (with eggs on different parts of plants), ware and seed potato tubers, re-used potato bags (with remaining eggs and possibly also pupae), infested soil (with eggs and pupae). Also the sudden occurrence of the moth in Tenerife is most likely an introduction of at least one bag with infested potatoes from some of the South American countries.

Economic aspects and importance

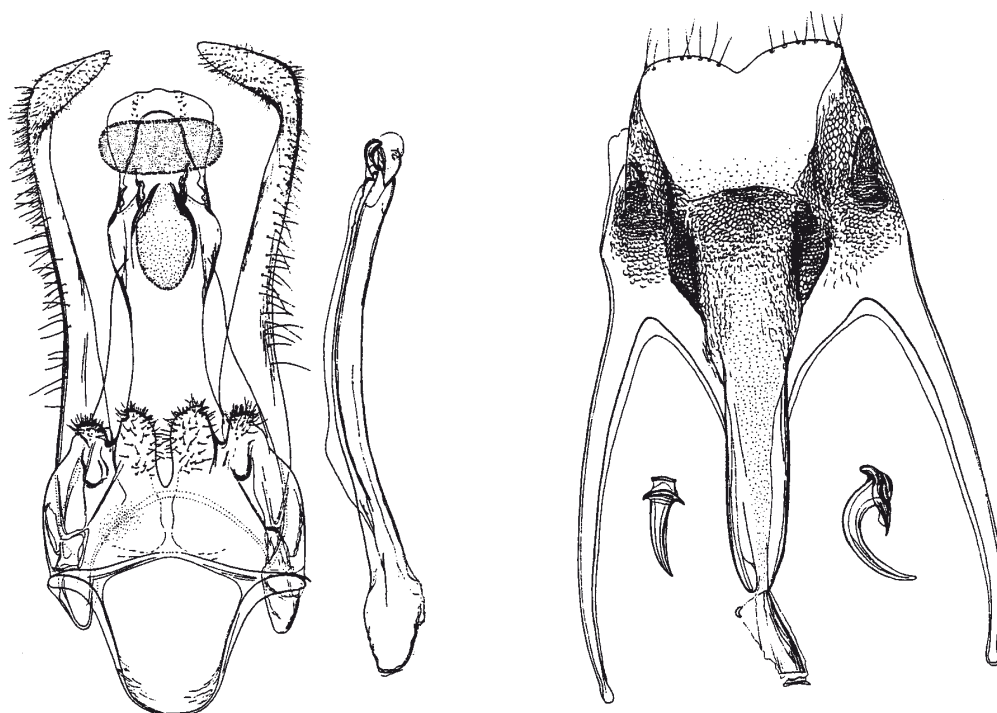
The first estimations of economic losses were related to Costa Rica (1972) where the infested potato

growing area was approximately 2.000 ha with losses corresponding to 20% - 40% and valued at 900.000 US Dollars. At present, damage up to 90% is reported especially from South America. (In Ecuador a crop may be completely destroyed within 3 months). In Central America damage may amount 40 % of the yield. Colombia attributed losses of more than 276.320 tonnes in 1994, and 4.4% in field cultures of potato, and 11.3 % damage in stored potatoes (Arias et al. 1996). The estimations (from local press) after the recent introduction of the moth in the north of Tenerife report of economic losses of at least 900.000 EURO in 2001, as the damage reduced the yield to 50%, and discussions arise about financial compensation for the growers.

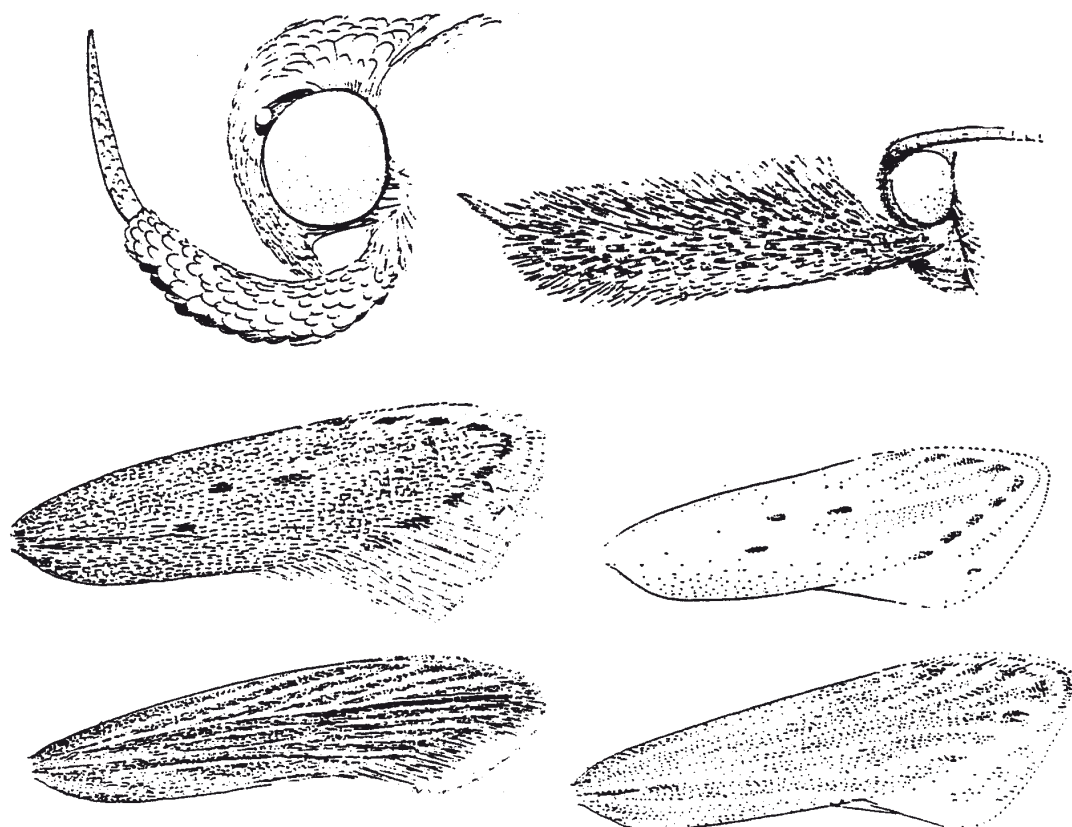
Control measures

These measures are developed in several directions. The synthesis of pheromones (Inoue et al. 1994 and PRECODEPA, 1989) enables the monitoring of populations before their outbreaks when densities become too high. The entomophagous mycoses (fungi), viz. *Beauveria bassiana* and *Metarrhizium anisopliae* (FERIS et GUTIERREZ, 2002) similarly as the use of the trichogrammatine parasitoid wasp *Trichogramma lapozandnensis* and *Copidosoma* sp. (RINCON-LOPEZ and LOPEZ, 1999) appear not to be very effective. The main direction of the control seems to be the use of granulovirus with its promising results. The chemical measures of control are poorly effective once the larvae have penetrated the tubers. Some agrotechnical measures might be practiced, e.g. covering the tubers with soil or their deep planting (to minimize the egg laying and access of caterpillars). The stored potatoes should be disinfested (space treatment with insecticide), and the tubers should be stored immediately after harvest. Only uninfested potatoes should be stored. Their treatment by granulovirus in indirect light and aeration together with pheromone traps (for monitoring, detection and control) should follow as soon as possible. The traditional bags should be substituted by thin polyethylene bags enabling the light entry between the tubers. Packing material should not be re-used. The information campaigns especially for growers offering informations (description of pest and control methods), installation of pheromone traps should follow in possibly endangered areas etc.

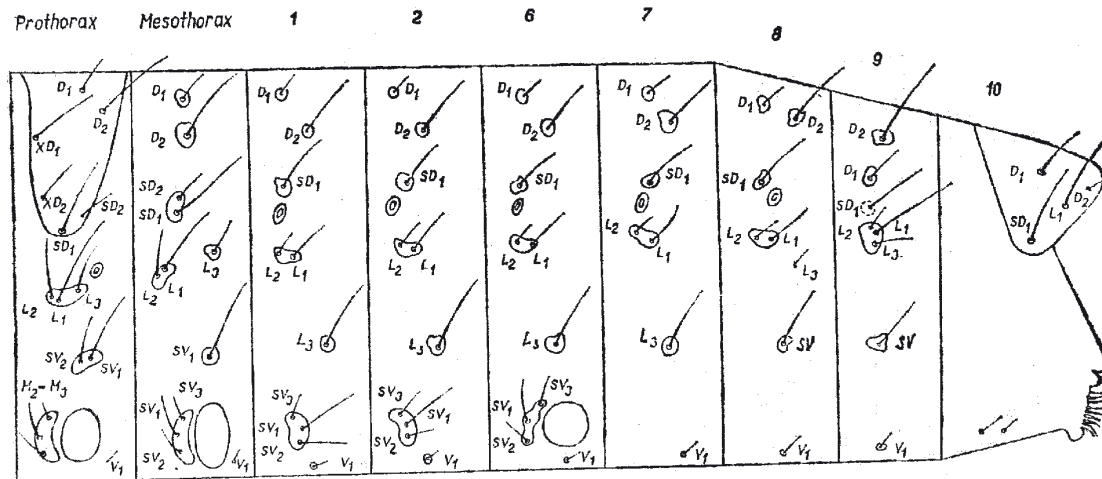
Scrobipalopsis solanivora is a quarantine insect as a characteristic „Allert Pest“. As it is now expected also in the southern countries of the European Plant Production Organisation (EPPO), it presents a high risk factor to these countries and adequate phytosanitary measures should be considered and realized as soon as possible.



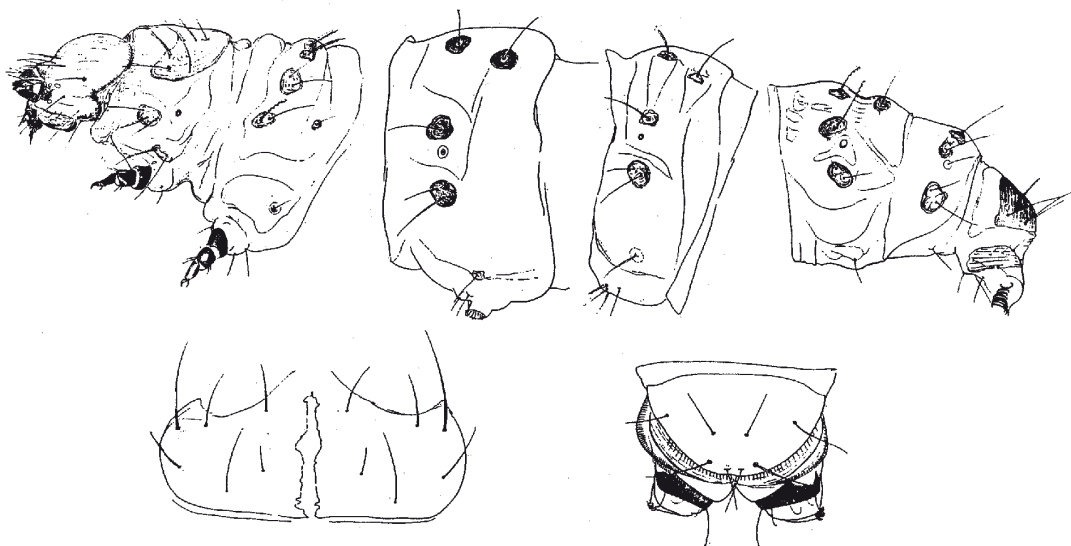
4: Male (left) and female (right) genitalia of *Phthorimaea operculella* (Zeller, 1873)



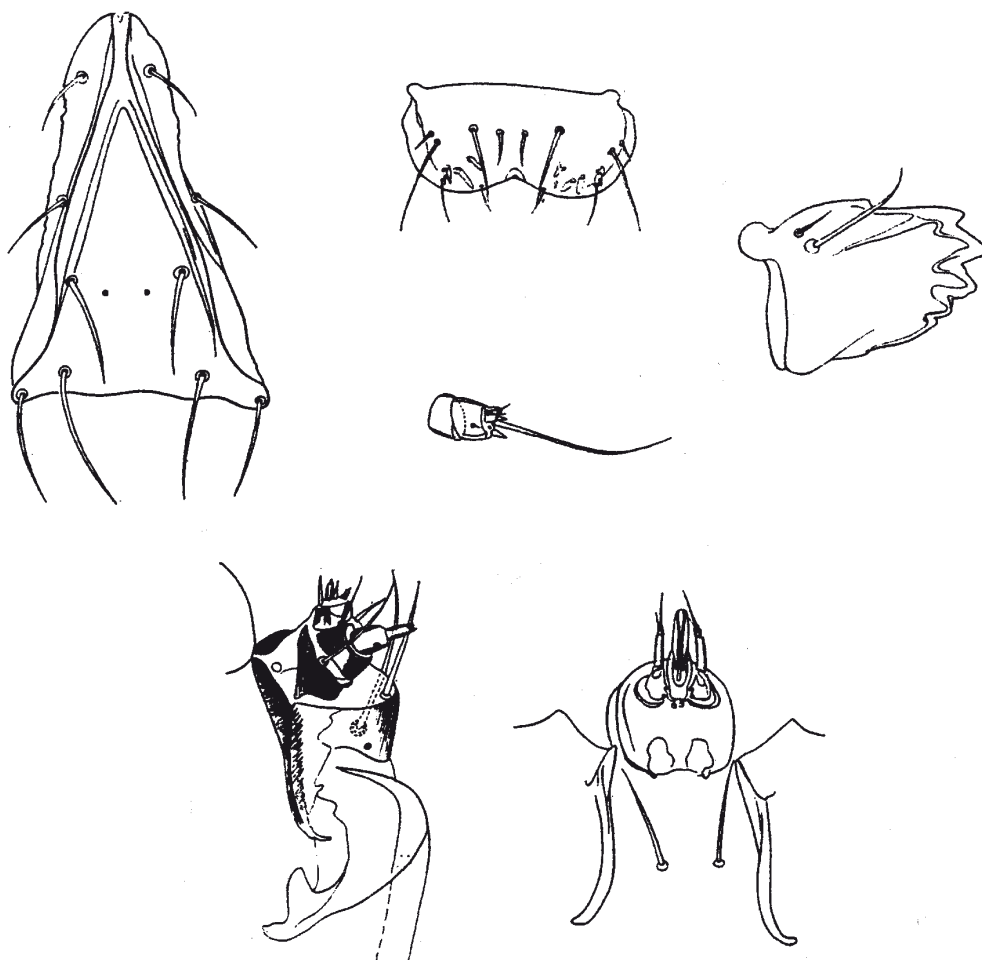
5: Labial palpus (top) and forewing pattern (middle) of: *Scrobipalopsis* (left) and *Tecia* (right); Forewing pattern of *Scrobipalopsis petasitis* (middle left); *Scrobipalopsis arnicella* (middle right); *Tecia venosa* (bottom right) and *Scrobipalopsis tetradymiella* Compare with coloured figures of *Scrobipalopsis solanivora* in this paper



6: General scheme („map“) of caterpillar chaetotaxy in gnorimoschemine moths showing all groups of setae. In specialized taxa (leaf-miners, gall-producers) a tendency towards the chaetotaxy reduction is observed.



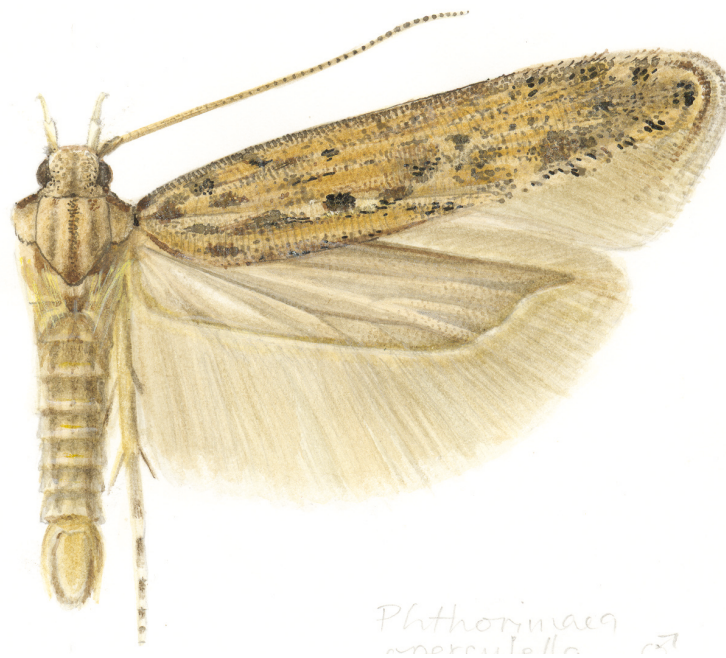
7: Chaetotaxy of fully grown caterpillar of *Scrobipalopsis solanivora* (top), prothoracic tergite (bottom left) and last abdominal segments (dorsal view, bottom right). A comparison with plate 6 shows that the caterpillar of *S. solanivora* shows practically all groups of chaetae characteristic of gnorimoschemine caterpillar and that they are fully developed. This indicates that the chaetotaxy of the caterpillar of *S. solanivora* shows no chaetotaxy adaptation like in the caterpillars of mining Gnorimoschemini and is consequently no mining form.



8: Mouth parts of caterpillar



Male (top) and female (bottom) of Guatemalan potato tuber moth (*Scrobipalopsis solanivora*). This insect pest is distinctly dimorphic (dichroism). The male is darker coloured than the female and its radiate forewing pattern is less distinct. Forewing length varies round 7 mm. The stouter female (forewing length more than 10 mm) is paler with distinctive forewing pattern. The insect is called „Polilla guatemalteca de papa“, „Polilla centroamericana“, „Palomilla de papa“, „Polilla gigante de papa“ (in Spanish); „Guatemalan potato tuber moth“ (in English), Teigne guatémaltèque de la pomme de terre“ (in French); „Grosse Kartoffelknollenmotte“, „Kartoffelminiermotte“ (in German). Original painting by A. Laštůvka.



The male of another gnorimoschemine moth attacking potato („Potato tuber moth“) – *Phthorimaea operculella*. This is another insect pest of South American origin attacking potato which has become secondarily cosmopolitan in potato growing subtropical and tropical countries (Povolný, 2002). Compared with *S. solanivora*, this moth is distinctly smaller (forewing length varies between 6 – 9 mm) more narrow-winged and showing no distinctive forewing pattern. Its caterpillars are leaf-miners and tuber-borers of both cultivated (potato, aubergine, tomato, papper, tobacco) and wild growing Solanaceae (*Solanum* sp. div., *Hyoscyamus*, *Datura*, *Physalis*). The damage by *Phthorimaea operculella* is more or less of local importance and it varies within the scale of many years. During hot seasons, this moth penetrates occasionally also Central Europe or it hatches from imported potato, but it does not survive more northerly climate. Its names are „Teigne de la pomme de terre“ (in French), „Palomilla de tubérculo“ (in Spanish), „Potato tuber moth“ (in English), „Kartoffelknollenmotte“, „Kartoffelminiermotte“ (in German). Original painting by F. Gregor.



*Heavy damage of a potato tuber by caterpillar infestation of *Scrobipalopsis solanivora*. The caterpillars bore tunnels and galleries later infested by bacteria and fungi so that the tuber is completely destroyed.*

Superficial feeding picture on potato tuber by 4th instar caterpillar and the circular opening of larva leaving the potato tuber before pupation. The dissected cocoon shows the pupating caterpillar (praepupa) and the neighbouring cocoon with the protruding pupa.

SOUHRN

Guatemalská makadlovka hlízová (*Scrobipalopsis solanivora* Povolný, 1973) před branami Evropy (Lepidoptera, Gelechiidae)

V r. 1973 popsal autor tohoto příspěvku do té doby neznámou makadlovku z čeledi Gelechiidae, kterou mu z Kostariky poslal k určení profesor entomologie tamní univerzity (v San José) Dr. Gilbert Fuentes, jako škůdce bramborových hlíz, zavlečeného do Kostariky údajně ze sousední Guatemaly. Ukázalo se, že jde o neznámý druh z této čeledi (Povolný, 1973). Již dva roky před tím se o identifikaci tohoto motýlka pokoušeli odborníci ve washingtonské Smithsonian Institution (Dr. R. W. Hodges) a z britského Commonwealth Institute of Entomology v Londýně (Dr. J. D. Bradley). Poslední z obou se identitě neznámého druhu nejvíce přiblížil a zasloužil se také o to, abych dostal místo původní tříšťa materiálu vypreparované motýlky a konzervované housenky. S více než třicetiletým odstupem se dnes ukazuje, že tato makadlovka je univerzálním škůdcem brambor, neboť fatálně napadá nejenom bramborové hlízy a rostliny v kulturách, nýbrž zejména pytlované brambory ve skladech. Zejména jimi se do konce minulého století rozšířil prakticky po všech jihoamerických státech, kde se pěstují a produkují brambory. Napáchané škody se vyčísľují na stamiliony. V současnosti postihuje tento škůdce bramborové kultury od 500 m n.m. až do 3000 m n.m. (např. v Ekvádoru). Počet generací je různý podle zevních (u pytlovaných brambor skladových) teplot. Za optimálních podmínek (při teplotách kolem 25 °C) se jedna generace makadlovky hlízové (od naklazení vajíček po líhnutí dospělců) vyvíjí něco více než 40 dní. V subtropích a tropech Jižní Ameriky však bylo v některých populacích pozorováno až 10 generací za rok. Počátkem našeho století byl odborný svět alarmován náhlou erupcí tohoto karanténního škůdce brambor jeho zřejmě ilegálním zavlečením na Kanárské ostrovy (jmenovitě Tenerife, kde způsobuje významné škody jak v kulturách, tak ve skladech). Tím byla znepokojena odborná veřejnost v Evropě (zejména ve Španělsku a Francii), takže European Plant Production Organisation (EPPO) začíná rozvíjet rozsáhlou informační akci bramborářských institucí zejména v západním Středomoří. V této studii se řeší otázka rodové taxonomie tohoto škůdce a souhrnně jsou probrány jeho bionomie, způsoby šíření, ekonomický význam a ochranná opatření.

makadlovka hlízová, škůdci brambor, bionomie, šíření, ochrana, Jižní Amerika, Kanárské ostrovy

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