Noctuidae moths occurring in grape orchards in Serra Gaúcha, Brazil and their relation to fruit-piercing

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ABSTRACT. Noctuidae moths occurring in grape orchards in Serra Gaúcha, Brazil and their relation to fruit-piercing. There is no study aiming to investigate if Noctuidae moths are responsible for piercing cultivated fruits in South America. This research aims to survey noctuid moths and list the species with mouth-parts (proboscis) morphology that suggest the capacity to cause damages to grape orchards in the state of Rio Grande do Sul, Brazil. Catches were carried out weekly from late November 2007 to late March 2008 (fructification period) using light traps and McPhail traps in three grape orchards in the region of Serra Gaúcha. The catches resulted in 187 taxa, with 149 identified at the specific level and 38 at genus level. The proboscises of representative taxa were removed and analyzed under stereomicroscope and scan electron microscope. It was verified that only *Oraesia argyrosema* (Hampson, 1926) and *Gonodonta biarmata* Guenée, 1852 show proboscis with suitable morphology for piercing rind and pulp of a grape berry. *Achaea ablunaris* (Guenée, 1852); *Ascalapha odorata* (Linnaeus, 1758); *Letis mineis* Geyer, 1827; *Mocis latipes* Hübner, 1823; *Ophisma tropicalis* Guenée, 1852, and *Zale exhausta* (Guenée, 1852) show proboscis only adapted to lacerate the pulp. The proboscis morphology of the remaining noctuid moths suggests lack of capacity to cause damage. Despite the presence of species capable of piercing grape berries, the populations of such species are very reduced and unable to cause damage of economic level.

KEYWORDS. Bait; fruit-piercing moths; light trap; McPhail trap; proboscis.

RESUMO. Mariposas Noctuidae presentes em parreirais na Serra Gaúcha, Brasil e sua relação com a perfuração dos frutos. Na América do Sul inexistem estudos que investiguem se noctuídeos adultos são responsáveis pela perfuração de frutos cultivados. Visando avaliar a ocorrência e listar as espécies que apresentam aparelho bucal (espirotromba) com morfologia que sugira a capacidade de causar danos à cultura da uva no Rio Grande do Sul, Brasil, foram realizadas coletas semanais entre o final de novembro de 2007 e o final de março de 2008 (período de frutificação) utilizando armadilhas luminosas e McPhail em três áreas de cultivo na Serra Gaúcha. As coletas resultaram em um total de 187 táxons, sendo 149 identificados ao nível específico e 38 ao nível genérico. A espirotromba de cada táxon identificado foi retirada e analisada em microscópio estereoscópio e microscópio eletrônico de varredura. Foi constatado que apenas *Oraesia argyrosema* (Hampson, 1926) e *Gonodonta biarmata* Guenée, 1852 apresentam espirotromba com morfologia própria para perfurar a casca e a polpa da baga da uva. *Achaea ablunaris* (Guenée, 1852); *Ascalapha odorata* (Linnaeus, 1758); *Letis mineis* Geyer, 1827; *Mocis latipes* Hübner, 1823; *Ophisma tropicalis* Guenée, 1852 e *Zale exhausta* (Guenée, 1852) apresentam espirotromba capaz apenas de dilacerar a polpa. As demais espécies apresentam espirotromba com morfologia inadequada para causar danos desta natureza. Apesar de ter sido constatada a presença de noctuídeos adultos capazes de perfurar bagas de uva, as populações destas espécies encontram-se muito reduzidas para causar danos econômicos.

PALAVRAS-CHAVE. Armadilha-luminosa; armadilha McPhail; isca; mariposas perfuradoras de frutos; probóscide.

Some noctuid moths, specially in the subfamily Calpinae (*sensu* Lafontaine & Fibiger 2006), show mouth-parts adapted to pierce both rind and pulp of fruits (Mosse-Robinson 1968), causing direct damage (primary fruit-piercing moths), whereas other species are just capable to cause indirect damage dispersing microorganisms by piercing the exposed pulp of already damaged fruits and inducing rottenness (secondary fruit-piercing moths) (Bänziger 1970).

Fruit-piercing moths occur mainly in the tropical regions, though the world occurrence of this kind of fauna is still unknown (Fay & Halfpapp 2006). The most important species, *Eudocima fullonia* (Clerck, [1874]) (Calpinae), occurring in Africa and Oceania is capable to feed on more than 100 species of fruits, including cultivated and native (Davis *et al.* 2005). There are reports of fruit damage in the Neotropical region for Central America, Mexico, and Jamaica (Anonymous *apud* Mosse-Robinson 1968). For the U.S.A., there are reports of damage caused in orange orchards in the state of Florida (King & Thompson 1958). In South America, Haji *et al.* (2001) reported a single case of damage caused by fruit-piercing moths. These authors verified damage in grape orchard in the Brazilian northeast region of Vale do Rio São Francisco during pest monitoring programs.

For the Serra Gaúcha region, in the Brazilian southernmost state of Rio Grande do Sul, which have the largest grape cultivated area in the country, there are no bibliographical data about damage caused by fruit-piercing moths. However, many producers reported massive presence of moths during the harvesting period and have associated their occurrence with damage similar to those caused by fruit-piercing moths.

This study was based upon the suspect of potential damage that would be caused by fruit-piercing moths and the presence of species of Calpinae in Rio Grande do Sul (Specht & Corseuil 1996, 1998, 2001, 2002a; Specht *et al.* 2004), and aimed: (1) to survey species diversity and abundance of noctuid moths occurring in grape orchards in Serra Gaúcha during ripening period; (2) to investigate the mouth-parts morphology of each species looking for evidence that corroborate to their piercing suitability; (3) to characterize the mouth-parts morphology of species capable to cause primary and/or secondary damage, and those of the species not capable to cause damage to grape berries.

MATERIAL AND METHODS

Insects and taxonomic state. The highest taxonomic categories included in this survey follow the systematic classification proposed for Noctuidae *sensu* Lafontaine & Fibiger (2006) that considered Arctiidae and Lymantriidae as subfamilies of Noctuidae. However, due to limitations of this classification at generic and specific level and aiming to allow the comparison with prior diversity studies of these groups, we chose to list the species and discuss according to classifications consolidated in literature. Thus, we followed Jacobson & Weller (2002) for Arctiinae, Kitching & Rawlins (1999) for Lymantriinae and Poole (1989) for other noctuid moths.

Periodicity and survey areas. The catches took place in two areas in the county of Bento Gonçalves (Vale dos Vinhedos, at 29° 10’9.34’’S; 51° 33’W and Pinto Bandeira, at 29°4’42.08’’S; 51°27’W) and one in the county of Farroupilha (Linha Jacinto, at 29°6’51.91’’S; 51°23’W) with weekly periodicity, from November 27th, 2007 to March 29th, 2008. In Pinto Bandeira and Farroupilha, besides the cultivation of grapes, there were many kinds of temperate fruits, such as peach, plum, khaki, kiwi fruit etc., whereas in Vale dos Vinhedos there were mainly grapes. There were extensive cultivated forests of *Eucalyptus* and *Acacia* in all three areas, besides a few remaining native forest islands.

Survey with light traps. A Pennsylvania model light trap (Frost 1957) powered by 12 volt battery and equipped with fluorescent lamp F15T12LN (Sylvania) with wavelength varying from 290 to 450 nanometers with peak around 340 nanometers was settled in each area. It was attached in the lower part of each trap a plastic conic shaft and a bucket containing 3 L of 70% ethanol (Specht *et al.* 2005). The traps were hung at about 2 m high above the soil level and switched on from late afternoon to early morning, left for approximately twelve hours during one night per week.

Survey with McPhail traps. Six McPhail traps individually baited with 200 g of attractive medium were settled randomly in each area. The attractive bait was made up of a mixture of 2 kg of fruits, including grape, apple and peach, 1½ L of white beer, 1 L of water and 1½ kg of sugar, maintained at 30°C by one day (Biezanko 1938). The traps were hung about 2 m high above the soil level and remained baited one night a week at the same period, however with a considerable distance from the light trap (>100 m). The food bait was collected every catch and reused twice before disposal and replacement with fresh bait.

Sorting and specimens identification. The samples obtained were sorted at the Laboratório de Biologia of the Universidade de Caxias do Sul (UCS), Campus Universitário da Região dos Vinhedos (CARVI). Representative specimens of each taxa were pinned and deposited in the Coleção da Universidade de Caxias do Sul (CUCS) as voucher specimens. The generic and when possible specific identifications were based on publications and examination of collections cited by Specht & Corseuil (1996, 1998, 2001, 2002a), Specht *et al.* (2004) and Teston & Corseuil (2002, 2003a, b).

Morphological analysis. The mouth-parts (proboscis) of each taxa collected were removed and analyzed under stereomicroscope with 60x magnification to search for evidence of their piercing suitability. Proboscises of representative species were dehydrated in 100% ethanol, followed by immersion in acetone for 15 minutes. To assure integrity of the proboscises, the water content of the samples was substituted by liquefied carbonic gas (Castro 2002) using critical point device Bal-Tech CPD030. Each proboscis was placed on an individual stub and fixed with carbon double-faced adhesive tape than sputter-coated with carbon and gold. The samples were analyzed under a scan electron microscope Philips XL 30 Series, at the Centro de Microscopia e Microanálises (CEMM) of Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS).

Data analysis. The data relative to the samples collected with the light and McPhail traps were organized according to occurrence and abundance of each taxa in each area, following alphabetical order by subfamily, tribe, sub-tribe, genus and species, considering, when possible, lower taxa as already mentioned (Tables I, II).

RESULTS AND DISCUSSION

Survey with light traps. A total of 3.007 noctuid moths of 187 taxa (Table 1) were collected from November 27th, 2007 to March 29th, 2008. Arctiinae and Lithosinae represented 31.8% of total individuals, including 74 taxa with 15 identified at genus and 59 at species level. *Episcea extravagans* Warren, 1901 is registered for the first time in Rio Grande do Sul. The number of specimens identified at species level corresponds to 15.26% of total Arctiinae referred to in Rio Grande do Sul (Ferro & Teston 2009). The relatively low percentage of Arctiinae species obtained in this study in relation to the ones referred to in Rio Grande do Sul may be attributed to the short period and dry weather during the survey. The lower catches may also be ascribed to the fewer sampling points in our research compared to the number recorded by Teston & Corseuil (2004) who obtained higher species richness

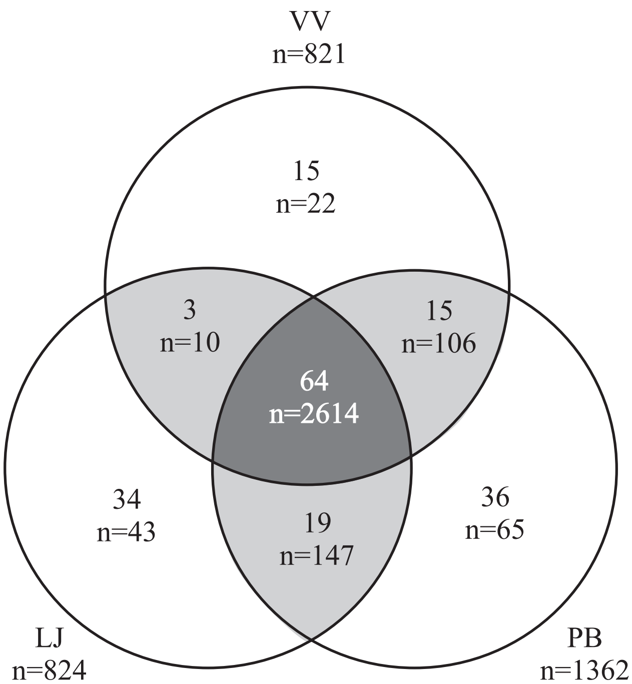


Fig. 1. Diagram of noctuid moths abundance and species richness in Linha Jacinto (LJ) (Farroupilha-RS), Pinto Bandeira (PB), and Vale dos Vinhedos (VV) (Bento Gonçalves-RS) captured with light traps during grape ripening period, from November 2007 to March 2008. Taxa with occurrence in one area are in white; in two areas are light gray; in three areas are dark gray.

in several different regions of Rio Grande do Sul during a two year survey and under variable climatic conditions. On another survey, Teston *et al.* (2006) obtained even higher species richness in a single night sampling than we obtained in four months. However, those authors's survey was carried out in conservation areas, what depicts that Arctiinae diversity depends on the degree of the environment conservation.

About 67% of the collected moths belonged to Noctuidae, grouped in 14 subfamilies *sensu* Poole (1989). This family represented the taxon with the highest richness in this survey, with 89 taxa identified to species level and 21 up to genus. The number of taxa identified at specific level corresponds to 19.82% of total Noctuidae referred to in Rio Grande do Sul (Specht & Corseuil 1996, 1998, 2001, 2002a; Specht *et al.* 2004). In relation to specific richness, it should be noted that Specht & Corseuil (2002b) obtained a similar result sampling in a contiguous area, even with systematic sampling for a considerably longer period of time. This discrepancy may be derived from climatic peculiarities, which happened during both surveys. On the other hand, Specht *et al.* (2005) obtained, in a single night in conservation areas of Rio Grande do Sul, higher species richness than that obtained in our survey. Once more, depicting the importance of environment conditions to favor diversity of Noctuidae *sensu* Poole (1989), as noted by Kitching *et al.* (2000).

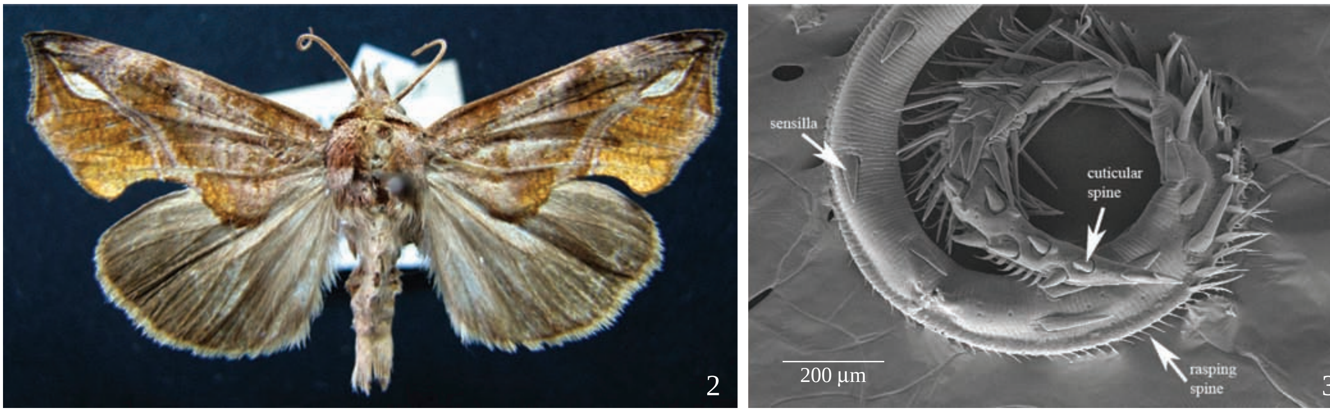
Less than one percent of total noctuid moths collected belonged to Lymantriinae, with only two species and one genus identified. The only species captured with more than one specimen in all three areas was *Thagona tibialis* (Walker, 1855), and just one specimen of *Sarcina violacens* (Herrich-Schaeffer, 1856) and one of *Sarcina* sp. were captured in Linha Jacinto (Table I). Due to lack of references about diversity of Lymantriinae, especially of Neotropical species (Kitching & Rawlins 1999) no comparisons on diversity were made.

The highest abundance was recorded in Pinto Bandeira (n=1362), followed by Linha Jacinto (n=824) and Vale dos Vinhedos (n=821) (Table I). It was verified differences in species composition in all three areas, as observed in conservation areas by Specht *et al.* (2005) and Teston *et al.* (2006). Linha Jacinto and Pinto Bandeira presented more than twice as many exclusive species than Vale dos Vinhedos (Fig. 1). The three surveyed areas presented similar numbers of simultaneous species; however, Linha Jacinto and Vale dos Vinhedos shared a much smaller number of species (Fig. 1). This difference in species composition can be attributed to predominance of grape orchards in Vale dos Vinhedos, whereas in Pinto Bandeira and Linha Jacinto there are also other fruits species being cultivated.

By analyzing the proboscis it was verified that only *Oraesia argyrosema* (Hampson, 1926) (Ophiderinae *sensu* Poole 1989) (Fig. 2) shows morphological adaptations capable of causing primary damage to the grape berries. The proboscis of this species (Fig. 3) is endowed with several inherent characteristics of primary fruit-piercing moths described by Bänziger (1970): thick cuticle; end portion sharp and cover with cuticular spines curved to the head used to tear the rind of fruits; the presence of probably erectable sensilla in lateral region of each galea; presence of rasping spines in dorsal edge of each galea, which are used to lacerate the pulp of fruit and increase the stability between both galeae.

Besides *O. argyrosema*, many species which were previously included in Catocalinae or Opiderinae *sensu* Poole (1989) and referred to in Rio Grande do Sul (Specht & Corseuil 1996, 1998, 2001; Specht *et al.* 2004) are nowadays included in Calpinae (Fibiger & Lafontaine 2005). Those species are included in the following genera: *Alabama* Grote, 1895; *Anomis* Hübner, 1816; *Anoba* Walker, 1858; *Eudocima* Billberg, 1820; *Goniapterix* Petry, 1833; *Gonodonta* Hübner, 1818; *Litoprosopus* Grote, 1869; *Plusiodonta* Guenée, 1852; and *Radara* Walker, 1862. The members of Calpinae are the true fruit-piercing moths due to their specialized proboscis (Speidel *et al.* 1996) which is capable to cause primary damage.

Some species of *Achaea* Hübner [1823], *Mocis* Hübner [1823] and *Ophisma* Guenée, 1852, not included in Calpinae by Lafontaine & Fibiger (2006), are referred either as primary or secondary piercers in Thailand (Bänziger 1982). However, the species included in these genera which were collected in this survey: *Acahea ablunaris* (Guenée, 1852), *Mocis latipes* Hübner, 1823, and *Ophisma tropicalis* Guenée, 1852 showed proboscis poorly adapted for piercing (Figs. 7, 8 and 9). Excepting in *A. ablunaris*, which shows a very sharp tip adapted for piercing soft rind fruits, the proboscis tips of the other species are relatively less sharp and endowed in dorsal edge, with rasping spines and sensilla which can probably act like rasping spines. Thus, these species are only capable to penetrate fruits by pre-existing holes in the berry. This



Figs. 2–3. *Oraesia argyrosema* – 2, Adult male; 3, proboscis tip.

kind of damage, characterized as secondary, may not be so important, since a primary damage must be already done. Notwithstanding, microorganisms present in the opened rind can be inoculated, accelerating the decay process (Bänziger 1982). Other species collected in this survey and not included in Calpinae by Lafontaine & Fibiger (2006) that may cause secondary damage are *Ascalapha odorata* (Linnaeus, 1758), *Letis mineis* Geyer, 1827, and *Zale exhausta* (Guenée, 1852) (Table I). These noctuid moths show proboscis tips with sensilla very similar to those found in fruit feeding Nymphalidae butterflies (Figs. 10, 11 and 12) (Krenn *et al.* 2001; Knopp & Krenn 2003).

It worthy emphasizing that in Rio Grande do Sul, in addition to the previously mentioned species there are four more included in the genus *Mocis* [1823], three in *Ophisma* Guenée, 1852, nine in *Letis* Lepeletier & Serville, 1828, and seven in *Zale* Hübner, 1818 (Specht & Corseuil 1996, 2001, 2002a; Specht *et al.* 2004), which probably show similar proboscises.

In relation to distinction between primary and secondary fruit-piercing moths, Bänziger (1982) mentions that even species with similar proboscises may show different piercing capability, since there are other factors than morphology of apical armature that contribute for piercing. Thus, to assess the piercing capability of a species with no doubt, specimens must be kept in a recipient with intact fruits. If the fruits are pierced after some days the species should be referred as primary for that kind of fruit.

The reduced number of specimens captured of previously mentioned species (Table I) can be attributed to climatic conditions, since the survey period was characterized as a very dry season. Similar observations were made by Bänziger (1982), who reports that populations of fruit-piercing moths are generally higher during rainy season in Thailand. Therefore, would be expected a much larger fruit-piercing moth species diversity, since there are twenty five Calpinae species referred to in Rio Grande do Sul (Specht & Corseuil 1996, 1998, 2001; Specht *et al.* 2004. However, periodic surveys of Noctuidae (Specht & Corseuil 2002b; Specht *et al.* 2005) show both low species richness and abundance of Calpinae species. The findings from this study suggest that for a complete evaluation of fruit-piercing moth populations, the catches should be done in several other regions with distinct climatic conditions, in other cultivated fruit orchards, along the seasons, and the study of larva feeding behavior and interactions between moths, host plants and natural enemies.

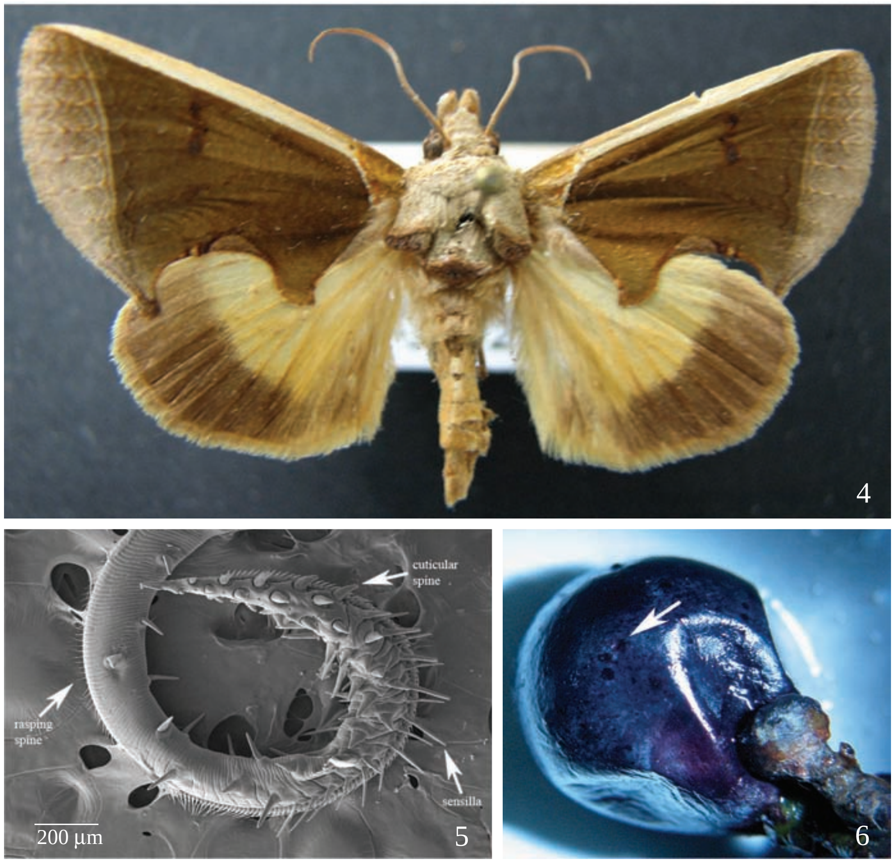
The species included in the remaining subfamilies could not cause primary or secondary damages, since their proboscises are not adapted for that behavior. All Plusiinae (Table I), in agreement with Speidel *et al.* (1996), show proboscis tip less sharp and with fewer and smaller cylindrical sensilla, as verified in *Rachiplusia nu* (Guenée, 1852) (Fig. 13), suggesting probably nectivorous feeding habits (Bänziger 1982). The proboscis of *Tripseuxoa strigata* Hampson, 1903 (Fig. 14) and those of species include in *Paracles* Walker, 1855 are less developed, indicating reduced or completely lack of feeding in adult stage.

The other noctuid moths surveyed show proboscis tip with cylindrical lateral sensilla and lamelliform structures on the dorsal portion of each galea edge with slight variation in number, form and size, as verified in *Bleptina confusalis* Guenée, 1852 (Fig. 15), *Anticarsia gemmatalis* Hübner, 1818 (Fig. 16), and *Cosmosoma auge* (Linnaeus, 1767) (Fig. 17).

It is noteworthy the presence of stamen attached to the proboscis of specimens of *Chabuata major* (Guenée, 1852) and *Heterochroma* sp. (Fig. 18), indicating nectivorous feeding habit, which is common among noctuid moths (Lingren *et al.* 1993; Hendrix *et al.* 1987). According to Bänziger (1982), it is not impossible, even for this species which have fewer and smaller sensilla, to scrap the exposed pulp of damaged fruits and feed on them. In the same way, many lepidopterans with well developed proboscises may explore several food sources, including damaged grapes with out-flowing liquid, to obtain mainly water, sugars, salts, and amino acids (Scoble 1995).

The lymantriid moths, as known, have very reduced mouth-parts, with no trace of proboscis (Scoble 1995) and, therefore, do not feed and are unable to inflict fruit damage, such as the species detected in this survey (Table I).

Therefore, we can not assume *a priori* that the occurrence of species with more than 100 specimens (Table I) is not associated (or at least partially associated) with available



Figs. 4–6. *Gonodonta biarmata* – 4, Adult female; 5, proboscis tip; 6, grape berry pierced by the moth.

damaged berries which can be use as food. However, this hypothesis is very unlikely because the occurrence of those species is associated with the presence of host plant for the larvae, since the majority of the species, excepting *B. confusalis*, are polyphagous and associated with cultivated plant groups and common grasses as ryegrass (*Lolium multiflorim* Lam.) (Specht & Corseuil 2002b).

Survey with McPhail traps. A total of 143 specimens belonging to four species (Table II) were collected in McPhail traps, including a single specimen of *A. gemmatalis* and three of *Gonodonta biarmata* Guenée, 1852. Together, *C. major* and *B. confusalis* represented 97.2% of the trapped specimens. Vale dos Vinhedos showed higher species abundance than the other areas (Table II).

The large number of *B. confusalis* may be associated to the presence of damaged berries in the grape orchards, which can be a potential food source. Another explanation is related to the large amount of organic matter normally found in agroecosystems, which is probably used as food by Herminiinae larvae (Kitching & Rawlins 1999). In the same way, the presence of a high number of *C. major* specimens can be associated to the presence of damaged berries. However, a more logical explanation would be that the polyphagous larvae *C. major* have plenty of food from corn, lettuce, carrot, and beet crops (Teran 1974) found in the surveyed area.

The only species collected exclusively in the McPhail traps was *G. biarmata* (Fig. 4), with one specimen captured in each area (Table II). This species belongs to Calpinae and show proboscis (Fig. 5) very similar to *O. argyrosema*, thus can potentially cause primary damage to grapes. Its capacity to cause damage was proven by a simple experiment, which one of the specimen collected during the catches was maintained in a recipient with intact grape berries, and by the fifth day it was verified characteristic perforations (Fig. 6), indicating that the moth had pierced the rind to feed on. Catches of *G. biarmata* in the traps do not mean that this species is associated to the grape orchard, but eventually to the khaki plants [*Diospyros kaki* L. – Ebenaceae] in nearby orchards (Silva *et al.* 1968; Specht *et al.* 2004; Todd 1959) which are host plants for its larvae.

Despite the extensive areas of *D. kaki*, the number of *G. biarmata* moths was extremely low in the McPhail traps (Table II). Like in the case of *O. argyrosema*, this fact may be attributed to the dry weather during the survey period or to the action of parasitoids and diseases. Observations made by the entomologist Ceslau Biezanko, from 1948 to 1970, indicated that *G. biarmata* was already rare in south Brazil (Specht *et al.* 2004), what may be an indication of naturally reduced populations. Another explanation for the low abundance verified is related to the reduced preserved native forest nearby the survey areas, where native fruit species are found, such as the Myrtaceae araçá [*Psidium cattleianum* Sabine], guava [*Psidium guajava* L.], guaviroba [*Campomanesia xanthocarpa* O. Berg], and pitanga [*Eugenia*

Table I. Noctuid moths captured weekly with light traps in Linha Jacinto (LJ) (Farroupilha), Pinto Bandeira (PB), and Vale dos Vinhedos (VV) (Bento Gonçalves-RS) during grape ripening period, from November 2007 to March 2008.

Taxa	LJ	PB	VV	Total
Acontiinae (*sensu* Poole, 1989)				
1. *Acontia ardoris* (Hübner [1827-1831])	1			1
2. *Acontia ruffinellii* Biezanko (1959)	1	1	1	3
3. *Cydosia rimata* Draudt, 1927			1	1
4. *Lithacodia mella* Schaus (1894)		2	1	3
	2	3	3	8
Acronictinae (*sensu* Poole, 1989)				
5. *Calymniodes conchylis* (Guenée, 1852)	1	5		6
	1	5		6
Amphipyrinae (sensu Poole, 1989)				
6. *Antachara diminuta* (Guenée, 1852)	1	1		2
7. *Antachara* sp.		1		1
8. *Bryolymnia bicon* (Druce, 1889)		7		7
9. *Callopistria floridensis* (Guenée, 1852)		1		1
10. *Condica cupentia* (Cramer, 1780)			1	1
11. *Condica selenosa* (Guenée, 1852)		2		2
12. *Condica stelligera* (Guenée, 1852)		2		2
13. *Condica sutor* (Guenée, 1852)	13	19	16	25
14. *Cropia plumbicincta* Hampson, 1908	1			1
15. *Elaphria agrotina* (Guenée, 1852)		3	1	4
16. *Elaphria deltoides* (Möschler, 1880)	6	2	9	17
17. *Elaphria jalapensis* (Schaus, 1894)		1		1
18. *Elaphria jonea* (Schaus, 1906)	1			1
19. *Elaphria marmorata* (Schaus, 1894)		1		1
20. *Elaphria subobliqua* (Walker, 1858)		1		1
21. *Elaphria* sp. 1	7	53	23	83
22. *Elaphria* sp. 2	1	2	2	5
23. *Elaphria* sp. 3		2		2
24. *Elaphria villicosta* (Walker, 1858)	9	5	7	21
25. *Hampsonodes naevia* (Guenée, 1852)	5	8	5	18
26. *Hampsonodes* sp. 1	2	6	2	10
27. *Hampsonodes* sp. 2	1			1
28. *Hampsonodes* sp. 3	2	7		9
29. *Hampsonodes* sp. 4	1	18	5	24
30. *Heterochroma chlorographa* Hampson, 1908		1		1
31. *Heterochroma* sp.	1	3	1	5
32. *Magusa orbifera* (Walker, 1857)		1	1	2
33. *Phosphila lacruma* (Schaus, 1894)			3	3
34. *Phuphena petrovna* (Schaus, 1894)	1			1
35. *Phuphena transversa* (Schaus, 1894)			1	1
36. *Pseudina albina* Hampson, 1910	1			1
37. *Spodoptera albula* (Walker, 1857)	1	1	5	7
38. *Spodoptera cosmioides* (Walker, 1858)	17	29	18	64
39. *Spodoptera dolichos* (Fabricius, 1794)	4	23	7	34
40. *Spodoptera eridania* (Stoll, 1782)		3		3
41. *Spodoptera frugiperda* (J. E. Smith, 1797)	6	21	25	52
42. *Spodoptera marima* (Schaus, 1904)		2	3	5
43. *Trachea anguliplaga* (Walker, 1858)	3	2	2	7
	84	228	137	449
Catocalinae (sensu Poole, 1989)				
44. *Achaea ablunaris* (Guenée, 1852)			4	4
45. *Mocis latipes* Hübner, 1823	1	4	8	13
46. *Ophisma tropicalis* Guenée, 1852	1	1	3	5
47. *Perasia* sp.	1			1
48. *Ptichodes basilans* (Guenée, 1852)		1	1	2
49. *Zale exhausta* (Guenée, 1852)	1			1
	4	6	16	26

Table I. Cont.

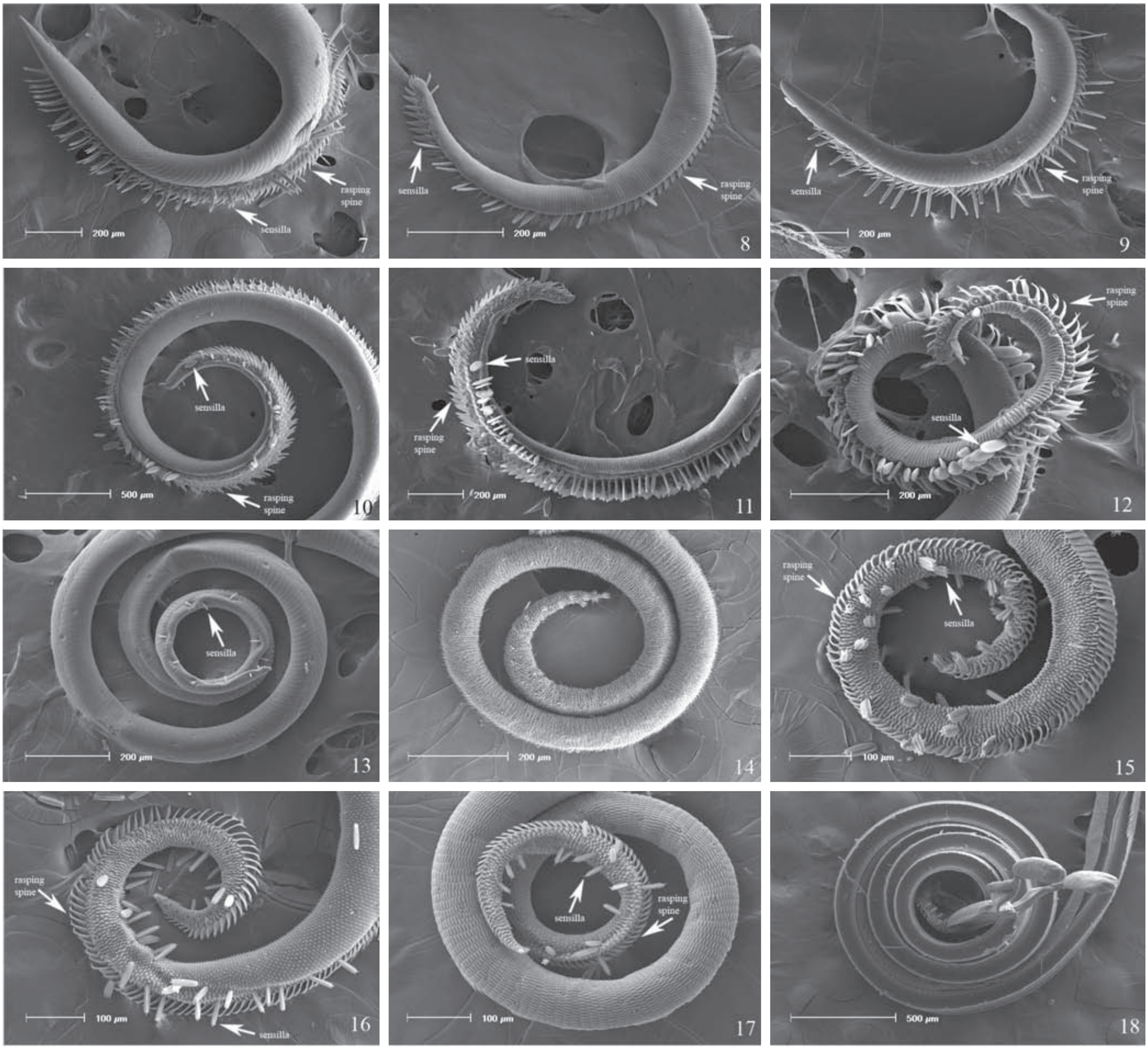
Taxa	LJ	PB	VV	Total
Bagisarinae (*sensu* Poole, 1989)				
50. Bagisara repanda (Fabricius, 1793)	2	3	6	11
51. *Bagisara* sp.1	2			2
52. *Bagisara* sp. 2		1		1
	4	4	6	14
Ophiderinae (*sensu* Poole, 1989)				
53. *Anticarsia gemmatalis* Hübner, 1818	20	65	22	107
54. *Ascalapha odorata* (Linnaeus, 1758)		1	1	2
55. *Coenipeta bibitrix* (Hübner, 1823)	1	2	6	9
56. *Coenipeta zenobina* (Massen, 1890)			1	1
57. *Hypocala andremona* (Stoll, 1781)			3	3
58. *Melipotis fasciolaris* (Hübner, 1831)	2	1	2	5
59. *Selenisa sueroides* (Guenée, 1852)			1	1
60. *Eulepidotis detracta* (Walker, 1858)			1	1
61. *Eulepidotis* sp.			1	1
62. *Encruphion leena* (Druce, 1898)		1		1
63. *Herminodes renicula* (C. Felder & Rogenhofer, 1874)		1		1
64. *Letis mineis* Geyer, 1827		1	1	2
65. *Licha undilinealis* Walker, 1850	1	1		2
66. *Oraesia argyrosema* (Hampson, 1926)	1	1		2
	25	74	39	138
Cuculiinae (*sensu* Poole, 1989)				
67. *Cucullia argyrina* Guenée, 1852		1		1
68. *Neogalea sunia* (Guenée, 1852)	1		2	3
	1	1	2	4
Euteliinae (*sensu* Poole, 1989)				
69. *Eutelia abscondens* (Walker, 1858)	1		2	3
70. *Paectes devincta* (Walker, 1858)	1			1
	2		2	4
Hadeninae (*sensu* Poole, 1989)				
71. *Chabuata major* (Guenée, 1852)	15	20	8	43
72. *Dargida meridionalis* (Hampson, 1905)			1	1
73. *Eriopyga approximans* Jones, 1908	13	11	4	28
74. *Eriopyga* sp. 1		2	1	3
75. *Eriopyga* sp. 2	2			2
76. *Eriopyga* sp. 3		1		1
77. *Faronta albilinea* (Hübner, 1821)	32	42	54	128
78. *Leucania albifasciata* (Hampson, 1905)	2	1		3
79. *Leucania humidicola* Guenée, 1852	25	27	35	87
80. *Leucania jaliscana* Schaus, 1898	1	1	2	4
81. *Leucania latiuscula* Herrich-Schäffer, 1868		8		8
82. *Leucania microsticha* (Hampson, 1905)		32	13	45
83. *Leucania* sp. 1		4		4
84. *Orthodes curvirena* (Guenée, 1852)	20	21	22	63
85. *Orthodes* sp. 1	71	98	70	239
86. *Orthodes* sp. 2	18	2		20
87. *Polia* sp.		4	1	5
88. *Pseudaletia adultera* (Schaus, 1894)	3			3
89. *Pseudaletia sequax* Franclemont, 1951	9	18	26	53
	211	292	237	740
Heliothinae (*sensu* Poole, 1989)				
90. *Helicoverpa gelotopoeon* (Dyar, 1921)		1		1
91. *Helicoverpa zea* (Boddie, 1850)	9	11	41	61
92. *Heliothis tergemina* (C. Felder & Rogenhofer, 1874)		1		1
93. *Heliothis virescens* (Fabricius, 1777)	2		2	4
	11	13	43	67
Herminiinae (*sensu* Poole, 1989)				
94. *Bleptina confusalis* Guenée, 1852	77	82	95	254

Table I. Cont.

Taxa	LJ	PB	VV	Total
95.*Bleptina* sp.	1			1
	78	82	95	255
Noctuinae (*sensu* Poole, 1989)				
96.*Agrotis ipsilon* (Hufnagel, 1766)	1	4	2	7
97.*Agrotis subterranea* (Fabricius, 1794)	1	1	4	6
98.*Anicla ignicans* (Guenée, 1852)	3	4	4	11
99.*Anicla infecta* (Ochsenheimer, 1816)	8	15	13	36
100.*Ochropleura cirphisioides* Köhler, 1955	2			2
101.*Peridroma saucia* (Hübner, 1808)	47	58	27	132
102.*Pseudoleucania butleri* (Schaus, 1898)		1	1	2
103.*Pseudoleucania messium* (Guenée, 1852)		1		1
104.*Tandilia rodea* (Schaus, 1894)		1		1
105.*Tripseuxoa strigata* Hampson, 1903		16	1	17
	62	101	52	215
Plusiinae (*sensu* Poole, 1989)				
106.*Autographa bonaerensis* (Berg, 1882)		1		1
107.*Autoplusia oxygramma*	1			1
108.*Plusia admonens* Walker, 1858	1	8	5	14
109.*Rachiplusia nu* (Guenée, 1852)	9	48	20	77
	11	57	25	93
Sarrothripinae (*sensu* Poole, 1989)				
110.*Iscadia aperta* Walker, 1857	2			2
	2			2
Arctiinae (*sensu* Jacobson & Weller, 2002)				
Arctiini (*sensu* Jacobson & Weller, 2002)				
111.*Hypercompe heterogena* (Oberthür, 1881)	2	2	15	19
112.*Hypercompe* sp.	1			1
113.*Isia alcumena* (Berg, 1882)	2	2	1	5
114.*Paracles bilinea* (Schaus, 1901)		2		2
115.*Paracles fervida* (Schaus, 1901)	1			1
116.*Paracles fusca* (Walker, 1856)	29	18	25	72
117.*Paracles* sp.	6	18		24
118.*Paracles variegata* (Schaus, 1896)	15	12	4	31
119.*Virbia divisa* (Walker, 1864)	11	3		14
	67	57	45	169
Ctenuchini (*sensu* Jacobson & Weller, 2002)				
120.*Aclytia heber* (Cramer, 1780)	1			1
121.*Aclytia terra* Schaus, 1896	1	2	4	7
122.*Argyroeides sanguinea* Schaus, 1896	2			2
123.*Delphyre roseiceps* Dognin, 1909		1		1
124.*Delphire* sp.		2	1	3
125.*Episcepsis endodasia* Hampson, 1898	1			1
126.*Eucereon arenosum* Butler, 1877		1		1
127.*Eucereon discolor* (Walker, 1856)			1	1
128.*Eucereon rosa* (Walker, 1854)	3			1
129.*Eucereon* sp.		4		4
130.*Eucereon striatum* (Druce, 1889)			1	1
131.*Nelphe cofinis* (Herrich-Schäffer, [1855])		3		3
132.*Philoros affinis* (Rothschild, 1912)	26	54	16	96
133.*Theages leucophaea* Walker, 1855		1		1
134.*Tipulodes ima* Boisduval, 1833		1	2	3
	34	69	25	128
Euchromiini (*sensu* Jacobson & Weller, 2002)				
135.*Aristodaema hanga* (Herrich-Schäffer, [1854])		1		1
136.*Cosmosoma auge* (Linnaeus, 1767)	3	1	1	5
137.*Cosmosoma centrale* (Walker, 1854)		1	1	2
138.*Cosmosoma* sp.	1	4		5
139.*Dycladia lucetius* (Stoll, 1781)		6	2	8
140.*Eurota helena* (Herrich-Schäffer, 1854)	4	6	7	17

Table I. Cont.

Taxa	LJ	PB	VV	Total
141.*Eurota herricki* Butler, 1876	29	95	2	126
142.*Macrocneme* sp.			1	1
143.*Phoenicoprocta analis* Schrottky, 1909		1		1
144.*Poliopastea* sp.	3	1	1	5
145.*Psilopleura sanguipuncta* Hampson, 1898		1		1
146.*Rhynchopyga meisteri* (Berg, 1883)	1	2		3
147.*Saurita cassandra* (Linnaeus, 1758)			1	1
	41	119	16	176
Pericopini (*sensu* Jacobson & Weller, 2002)				
148.*Dysschema hilarina* (Weymer, 1914)	1	1		2
149.*Dysschema sacrifica* (Hübner, [1831])	4	2	3	9
150.*Episcea extravagans* Warren, 1901	6	18		24
151.*Euchlaenidia transcisa* (Walker, 1854)	3	4	1	8
	14	25	4	43
Phaegopterini (*sensu* Jacobson & Weller, 2002)				
152.*Agaraea semivitrea* Rothschild, 1909	5	1		6
153.*Agaraea* sp.	1			1
154.*Baritius acuminata* (Walker, 1856)	8	13	14	35
155.*Bertholdia soror* Dyar, 1901	13	22	5	40
156.*Biturix rectilinea* (Burmeister, 1878)	4	2		6
157.*Demolis albicostata* Hampson, 1901		1		1
158.*Elysius pyrostica* Hampson, 1905	2			2
159.*Halysidota pearsoni* Watson, 1980	1			1
160.*Halysidota striata* Jones, 1908	1			1
161.*Hyalarctia sericea* Schaus, 1901	1			1
162.*Hyperthaema signatus* (Walker, 1862)	1	1	3	5
163.*Hyperthaema* sp.	17	1	1	19
164.*Hypidalia enervis* (Schaus, 1894)	1			1
165.*Idalus agastus* Dyar, 1910	2	2		4
166.*Leucanopsis coniota* (Hampson, 1901)	5	12	7	24
167.*Leucanopsis oruba* (Schaus, 1892)	1			1
168.*Leucanopsis* sp.	2	2	1	5
169.*Lophocampa* sp.	5	1	2	8
170.*Machadoia xanthosticta* (Hampson, 1901)	10	3	13	26
171.*Mazaeras conferta* Walker, 1855	2			2
172.*Mazaeras janeira* (Schaus, 1892)	1			1
173.*Melese chozeba* (Druce, 1884)		3		3
174.*Melese* sp.	1			1
175.*Neritos repanda* Walker, 1856	7	2	1	10
176.*Opharus procroides* Walker, 1855	2	2		4
177.*Ormetica chrysomelas* (Walker, 1856)	5	4	2	11
178.*Paraeuchaetes aurata* (Butler, 1875)	3	20	4	27
179.*Pelochita cinerea* (Walker, 1855)	11	24	5	40
180.*Phaegoptera albimacula* (Jones, 1908)		1		1
181.*Symphlebia lophocampoides* R. Felder, 1874	2			2
182. *Symphlebia* sp.		1		1
183. *Tessellarctia semivaria* (Walker, 1856)	1	4		5
	115	122	58	295
Lithosiinae (*sensu* Jacobson & Weller, 2002)				
184. *Agylla* sp.	40	98	8	146
	40	98	8	146
Lymantriinae (*sensu* Kitching & Rawlins, 1999)				
185. *Sarcina* sp.	1			1
186. *Sarcina violacens* (Herrich-Schaeffer, 1856)	1			1
187. *Thagona tibialis* (Walker, 1855)	13	6	8	27
	15	6	8	29
TOTAL	824	1362	821	3007



Figs. 7–18. Proboscis tips of Noctuidae moths: 7, *Achaea ablunaris*; 8, *Mocis latipes*; 9, *Ophisma tropicalis*; 10, *Ascalapha odorata*; 11, *Letis mineis*; 12, *Zale exhausta*; 13, *Rachiplusia nu*; 14, *Tripseuxoa strigata*; 15, *Bleptina confusalis*; 16, *Anticarsia gemmatalis*; 17, *Cosmosoma auge*; 18, *Heterochroma* sp.

uniflora L.], and the Annonaceae quaresma [*Annona cacans* Warm.], which can be serve as host plants for larvae and adult. In fact, some moths from the genus *Gonodonta* have already been observed piercing tropical native fruits as sugar apple [*Annona squamosa* L. Annonaceae] (Todd 1959). Among the plants reported as *Gonodonta* species host plants are orange, tangerine, and grapefruit (Todd 1959), which rots due to the several perforations made by the moths that let oxygen get inside. Damaged fruits can attract secondary fruit-piercing moths and be attacked by saprophytic flies and beetles (Todd 1959).

The McPhail trap was more effective than the light trap to study *G. biarmata* populations, though only three specimens have been captured. It can be attributed to the probably low attractiveness of *G. biarmata* to light, as verified in *E. fullonia* (Kumar & Lal 1983). The bait composition and the period of time during which it was used before disposal and replacement may be contributed to the reduced abundance of fruit-piercing moths captured in McPhail traps. Landolt (1995) evaluated different kinds of baits to capture *M. latipes* and verified that different concentration baits show distinct degrees of attractiveness that is reduced by the third day of preparation. The bait composition and the fact that it was use for fifteen days may be negatively influenced the bait attractiveness. However, during the study of ecological aspects of fruit-piercing moths in Thailand, Ngampongsai *et al.* (2005) obtained high species diversity and relatively high abundance using pineapple pieces kept for one week in the traps. It worthy emphasize that in addition to the previously mentioned factors, the McPhail trap design would negatively

Table II. Noctuid moths captured weekly with McPhail traps in Linha Jacinto (LJ) (Farroupilha), Pinto Bandeira (PB), and Vale dos Vinhedos (VV) (Bento Gonçalves-RS) during grape ripening period, from November 2007 to March 2008.

Taxa	LJ	PB	VV	Total
Noctuidae *sensu* Poole, 1989				
Hadeninae				
1. *Chabuata major* (Guenée, 1852)	12	20	50	82
	12	20	50	82
Herminiinae				
2. *Bleptina confusalis* Guenée, 1852	4	6	47	57
	4	6	47	57
Ophiderinae				
3. *Anticarsia gemmatalis* Hübner, 1818	1			1
4. *Gonodonta biarmata* Guenée, 1852	1	1	1	3
	2	1	1	4
TOTAL	18	27	98	143

affected the attractiveness; thus, it is necessary to compare the effectiveness of other kinds of traps.

As a conclusion, we found that among the noctuid species occurring in the studied grape orchards during fructification period, only a very low number of moths show proboscis with morphology able of causing primary fruit-damage, particularly the Calpinae species *G. biarmata*. Obviously, more studies about fruit-piercing moths in Brazil are needed, especially in fruit producer regions, aiming to find out the potentiality of these insects to cause damage. The most completely method to evaluate the fruit-piercing moth populations is using bait and light traps simultaneously, testing several kinds of traps and baits. Studies to determine the size and distribution of populations, immature stages, parasitoids and host plants of the larvae of fruit-piercing moths are needed. It is also important to do field nocturnal observations and laboratory experiments aiming to evaluate the piercing capacity of each species.

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