Peristenus varisae spec. nov. (Hymenoptera: Braconidae) parasitizing the European tarnished plant bug, *Lygus rugulipennis* Poppius (Heteroptera: Miridae)

A.-L. Varis & C. van Achterberg

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Anna-Liisa Varis, Department of Applied Biology, University of Helsinki, Finland (e-mail: avaris@millipede.helsinki.fi).
C. van Achterberg, Afdeling Entomologie (Hymenoptera), Nationaal Natuurhistorisch Museum, Postbus 9517, 2300 RA Leiden, The Netherlands (e-mail: achterberg@naturalis.nnm.nl).

Key words: Hymenoptera; Braconidae; Euphorinae; *Peristenus varisae*; new species; *Peristenus relictus* syn. nov.; Finland; Norway; native parasitoid; habitat structure; synchrony; Heteroptera; Miridae; *Lygus rugulipennis*.
Nymphs and adults of *Lygus* species, mainly *L. rugulipennis* Poppius were collected from wheat fields in southern Finland, near Helsinki. The parasitization rate of braconid species was determined by dissection of the hosts. Parasitoids were reared from separate samples from the same fields.The parasitization rate was low, the maximum percentage occurring during the season, examined in 10-day periods, was 14%. All nymphal instars, except the first one, were found to be parasitized; the mean varied from 3% (third instar) to 6.5% (fourth instar). In adult hosts the mean parasitization rate was 2% in males and 4% in females. The percentage of parasitization in both nymphs and adults was higher in wheat bordering fields with a mixture of field bean and oats or settled areas compared with wheat adjacent to cereal or sugar beet areas. However, the total numbers of *Lygus* and of unparasitized specimens were higher in these surroundings. Parasitization of *Lygus* species in Finland appears to be too low to affect the populations. It was ascertained that the new species of *Peristenus* parasitized in *L. rugulipennis*. Its possible presence in other *Lygus* species was not confirmed in this study. The life cycle of the parasitoid was in synchrony with the development of the host. The *Peristenus* species in question did not fit in the keys to any described species and is described in this article as new to science. A key to the *Peristenus* species reared from *Lygus rugulipennis* in Europe is added. *Peristenus stygicus* Loan, 1973, is synonymized by the second author with *P. relictus* (Ruthe, 1856) syn. nov.

Introduction

The European tarnished plant bug, *Lygus rugulipennis* Poppius, 1911 (Heteroptera: Miridae), is the most common *Lygus* species in many European countries (e.g., Bilewicz, 1958; Varis, 1959; Boness, 1963). In a long-term survey of *Lygus* populations in which weekly samples were taken from 8 field crops during 16 successive years in southern Finland, *L. rugulipennis* constituted 92% of the total number of adults (Varis, 1995). On wheat the proportion was even higher: 97%. The other *Lygus* species occurring on wheat were *L. gemellatus* (Herrich-Schaeffer, 1835) 2% and *L. pratensis* (Linnaeus, 1758) 1%; and some specimens of *L. punctatus* (Zetterstedt, 1840) were also found. According to existing literature *L. rugulipennis* is known to be parasitized by three *Peristenus* species (Hymenoptera: Braconidae: Euphorinae) all with the occipital carina widely reduced dorsally (as in the new species): *P. rubricollis* (Thomson, 1891), *P. digoneutis* Loan, 1973 and *P. stygicus* Loan, 1973 (Bilewicz-Pawińska 1982). These parasitoids have been found to reduce numbers of *L. rugulipennis*, and since the North American *Lygus* species lack effective native parasites, successful establishment of

European *Peristenus* species in the USA has occurred (e.g., Day et al.,1990; Day, 1996).

The parasitoids of *Lygus* species have not previously been studied in Finland. It has only been recorded that the eggs of *L. rugulipennis* are parasitized by *Anaphes fuscipennis* Haliday, 1833 (Hymenoptera: Mymaridae; Varis, 1972). The purpose of the present study was to investigate the occurrence and role of *Peristenus* species on *Lygus* bugs in Finland. A preliminary report of part of this study is given in Varis (1998).

Materials and methods

The present study was undertaken between 1978 and 1986 in southern Finland, near Helsinki. Nymphs and adults of *Lygus* species, mainly *L. rugulipennis*, were collected weekly from wheat fields 10-20 ha in size with a sweep net, starting when the fourth and fifth instar nymphs began appearing (about mid-July) and continued until late August. The parasitization rates of both nymphs and adults were determined by dissection of the hosts. Seasonal occurrence of parasitoids was compared with that of *Lygus* bugs in sweep-net samples taken from wheat in the same area in a 16-y period 1955-1970 (Varis, 1995). In the present study comparison was also made between two field types: a) wheat field areas bordering either fields with a mixture of field bean and oats or settled areas and b) wheat fields adjacent to cereal or sugar beet areas. The results were analysed with analysis of variance (ANOVA). To identify the parasitic species, separate sweep-net samples taken from the same fields were placed on potted scentless mayweed (*Tripleurospermum inodorum* (Linnaeus)) plants in rearing cages. To pupate, the parasitic larvae burrowed into the soil through a fine-meshed wire screen placed above the soil surface to prevent the attack of host insects. Possible emergence of parasitoids was monitored. At the end of the season the cocoons were collected from the soil, wrapped in soft tissue and placed in boxes containing soil. The boxes were kept in a refrigerator at 4-7°C and 65-80% relative humidity until the following spring when they were moved into rearing cages and kept at about 20°C. The parasitoids were removed on emerging.

Results and discussion

Synchrony between parasite and host.— *Peristenus* species are known to oviposit in the early instar nymphs of mirids. Final instar larvae emerge either from the fifth-instar nymphs or adults for pupation (Brindley, 1939).The development of the species is rather long; e.g. in *P. rubricolli*s it requires 47 days in the laboratory from the start of the egg period to pupation (Bilewicz-Pawińska, 1982). In this study the first parasitoids were found from the second-instar nymphs in mid-July. The rate of parasitization was highest in the second half of July and the first half of August (fig. 1). In a previous long-term study, hibernated *Lygus* adults appeared on wheat in the second half of May immediately after sprouting (Varis, 1997). The numbers of overwintered adults were small. The first nymphs were caught in the second half of June, and the peak occurred from mid-July to mid-August. The peak of new adults occurred in the first half of August when the bugs were concentrated on the developing grains. The life cycle of the parasitoid appears to be in synchrony with development of the *Lygus* host (fig. 1).

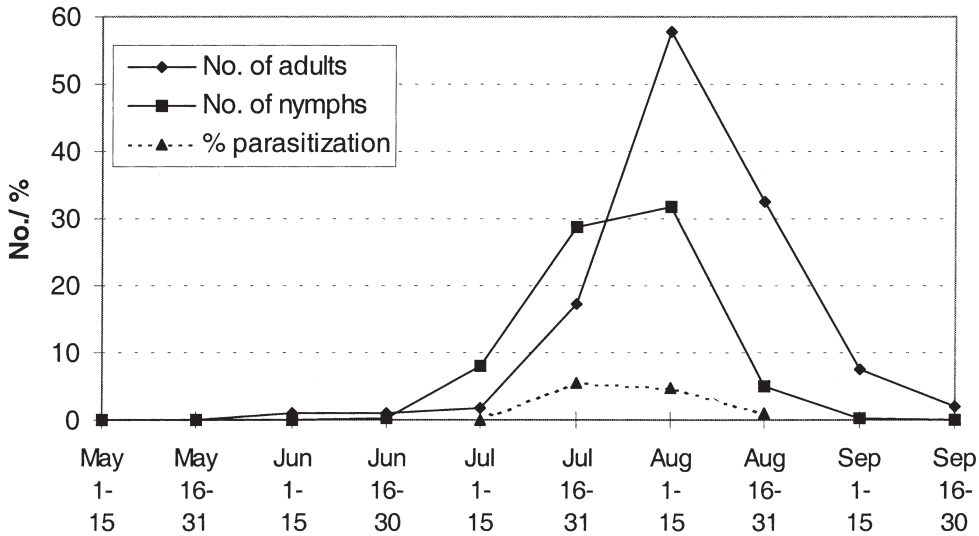


Fig. 1. Seasonal occurrence of parasitoids in *Lygus* hosts on wheat (this study) compared with that of *Lygus* nymphs and adults on wheat (16 y means, Varis, 1997).

Emergence of parasitoids.— The *Peristenus* species found during this study diapaused at the pupal stage in cocoons, as did also *Peristenus* species attacking *L. rugulipennis* in Poland. The pupal stage for Polish species lasts 8-10 months (Bilewicz-Pawińska, 1982), and the minimum time needed to interrupt the diapause was at least 2.5-3.5 months. When the temperature was raised earlier the braconid parasitoids died. In all species emergence began earlier when the diapause had lasted longer (Bilewicz-Pawińska & Varis, 1990). In the present study, the cocoons from sweepings in late July or in August were brought in the laboratory the following March. The emergence began after one week and lasted about one month. No parasitoids emerged during the previous autumn. It was ascertained that the *Peristenus* parasitoids were found in *L. rugulipennis*. Their possible presence in other species was not confirmed in this study. The parasitization rate was low. The maximum percentage of parasitization during the season, examined over 10-day periods, was 14% when recorded in early August 1981 (table 1). All nymphal instars, except the first were

Table 1. Seasonal parasitization in *Lygus* specimens (nymphs and adults) on wheat in Finland. The numbers of dissected specimens are given in table 3. The parasitization rates during 1981-1983 are also given in Bilewicz-Pawińska & Varis (1985).

Year	Parasitization %			
	July	August		
	15-31	1-10	11-20	21-31
1978	0	0	0	0
1979	0	4.5	12.1	0
1981	8.0	13.6	9.0	1.0
1982	0	0	0	0
1983	5.6	4.6	-	-

Table 2. Parasitization in *Lygus* specimens on wheat at different developmental stages: a) number of dissected specimens, b) percentage of parasitization.

	I		II		III		IV		V		Males		Females	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b
1979	-	-	4	0	58	5.2	61	8.2	101	6.9	4	0	21	0
1981	3	0	14	14.3	17	0	39	7.7	77	7.8	37	5.4	36	2.8
1982	-	-	-	-	5	0	22	0	129	1.6	190	0	253	0
1983	6	0	14	0	87	2.3	171	6.4	610	5.1	288	3.1	381	7.1

found to be parasitized (table 2). The parasitization rate was highest in nymphs from third to fifth instar, the mean varying from 3% (third instar) to 6.5% (fourth instar). In adults the mean parasitization rate was 2% in males and 4% in females. Bilewicz-Pawińska (1969) found that the parasitization rate of *L. rugulipennis* adults in Poland was by far smaller than that of nymphs. The author assumed that *Lygus* adults are not attacked by *Peristenus* species; the parasitoid larvae found in adults are only completing their development already begun in nymphs. In the present study the parasitization rates were small in both cases, and no remarkable differences could be observed (table 3). In general the rate of parasitization in Finland is probably too low to affect the populations. During the time of the present study the *Lygus* populations were relatively low. It has been observed that in populations occurring in small numbers either a low percentage of individuals is parasitized or they are totally free of parasitoids (Bilewicz-Pawińska, 1982), which was also seen here. The parasitization rates were higher in areas with higher *Lygus* populations (table 4).

Influence of habitat structure.— In wheat areas bordering fields with a mixture of field bean and oats or settled areas the absolute numbers of parasitized *Lygus* were greater than in wheat adjacent to cereal or sugar beet areas (table 4). Although the total numbers and also numbers of unparasitized bugs were higher in the first cases mentioned, the percentage of parasitization in both nymphs and adults was higher in these areas than in wheat bordering cereal or sugar beet areas. The reasons for the higher numbers of hosts as well as parasitoids may be both biotic and abiotic. Since the habitats in this study were situated in the same open area, the macroclimate was similar and was not considered to affect the numbers of *Lygus* and their parasites differently, whereas the microclimate in field areas bordered by sheltering vegetation may have been an increasingly influential factor. Bilewicz-Pawińska (1982) stated that grassland adjacent to cereal crops may be a source or harbour of parasitoids, which

Table 3. Parasitization in *Lygus* nymphs and adults on wheat in Finland.

Year	Number of dissected nymphs	Parasitization %	Number of dissected adults	Parasitization %
1978	122	0	120	0
1979	224	6.8	25	0
1981	150	7.3	72	2.8
1982	105	0	313	0
1983	888	5.0	669	5.4

Table 4. Effect of habitat structure on the numbers of *Lygus* specimens and their parasitoids in 1983 (2 experimental areas) and 1986. Mean numbers per 10×25 sweeps. A) wheat fields bordering areas with a mixture of field bean and oats or settled areas, B) wheat fields adjacent to sugar beet or cereal areas.

	A Mean SE	B Mean SE	F value
Number of *Lygus* specimens	128.0 ± 9.30	59.7 ± 5.66	79.4***
Number of parasitoids	4.0 ± 0.75	0.8 ± 0.41	21.8***
Mean rate of parasitization, %	3.7 ± 0.72	1.3 ± 0.49	9.1**

** P< 0.01; *** P <0.001

may locate their hosts in early spring when cereal crops are at the younger stages of growth and are not populated by bugs. Landis et al. (2000) have suggested that habitat management is an interesting approach to favouring natural enemies in agricultural systems. Since *Lygus* species are significant pests of numerous agricultural crops in many parts of the world, the possibility of increasing their natural enemies by habitat management is an interesting, although complicated area of study.

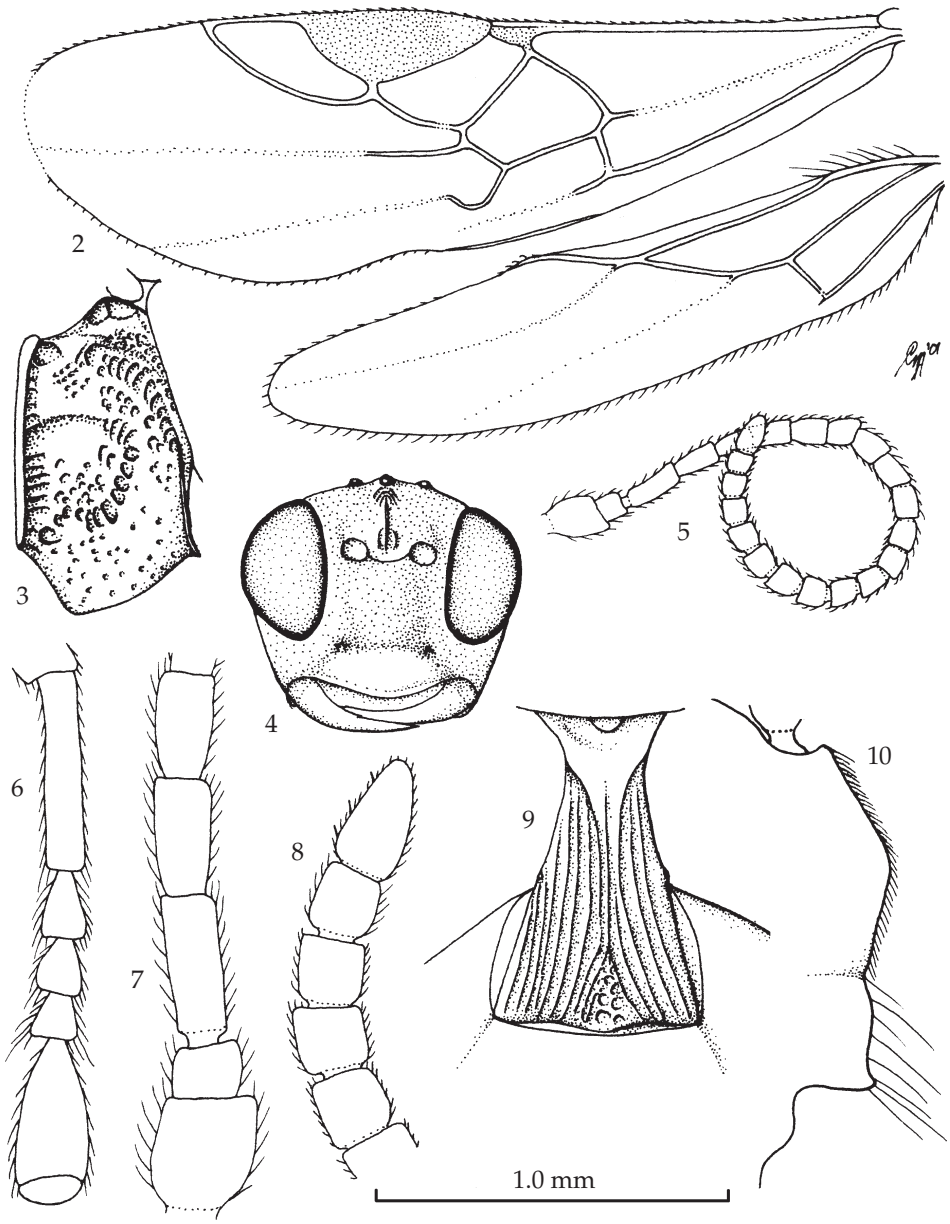
Specimens of emerged braconid adults were sent to Dr Conrad Loan (Ontario, Canada), who stated that the specimens belonged to the genus *Peristenus* but did not run in his European key to described species (information by letter). According to the second author, who is working on a revision of the genus *Peristenus* of the West Palaearctic it concerns a new species, which is described below.

Peristenus varisae van Achterberg, spec. nov. (figs 2-10)

Material.— Holotype, ♀ (RMNH), "Finland, 668: 39, N: Helsinki, Viikki, 5.viii.1986, A.-L. Varis et al.", "e.l. *Lygus* sp. [= *Lygus rugulipennis* on wheat]". Paratypes (2 ♂♂, RMNH): 1 ♂, topotypical and same host, but 28.viii.1985; 1 ♂, "Norway: Austmarken, nr Lake Utgardsjben, vi.1976, P. Kanaar, RMNH'77".

Diagnosis.- Antennal segments of ♀ 22-23, of ♂ 24-25; third antennal segment about twice as long as wide and about as long as fourth segment, and subapical segments of ♀ subquadrate (figs 5, 7, 8); face dark reddish-brown and moderately densely and rather short whitish setose; face of ♀ evenly bulging (fig. 10) and distinctly transverse, its minimum width about 1.5 times height of face (fig. 4; measured medially and from level of epistomal suture to lower rim of antennal sockets); pronotum largely or entirely dark brown; clypeus entirely or largely dark reddish-brown; occipital carina widely absent dorsally and moderately developed laterally, ventrally joining directly hypostomal carina; frons sparsely punctate and with long median carina (fig. 4); side of pronotum largely sculptured; mesopleuron above precoxal sulcus remotely and rather coarsely punctate (fig. 3); notauli deep and distinctly crenulate; vein 1-R1 of fore wing about as long as width of pterostigma and about 0.5 times as long as pterostigma (fig. 1); hind femur and basal half of antenna yellowish.

Notes.- Males of the West Palaearctic *Peristenus duplobrevicornis* (Shenefelt, 1969) have also a comparatively transverse face but have the mesoscutum coarsely punctate, the clypeus orange-yellowish, the face long silvery setose and the antenna largely yellowish. The East Palaearctic *P. furvus* Chen & van Achterberg, 1997, from China has a



Figs 2-10, *Peristenus varisae* spec. nov., holotype, ♀. 2, wings; 3, mesopleuron; 4, head, frontal aspect; 5, antenna; 6, fore tarsus, dorsal aspect; 7, base of antenna; 8, apex of antenna; 9, first metasomal tergite, dorsal aspect; 10, face and clypeus, lateral aspect. 2, 4-5: 1.0 × scale-line; 3: 1.2 ×; 6-8, 10: 2.4 ×; 9: 1.6 ×.

similar dark brown bulging face and the third antennal segment of ♀ may be also 2.7 times as long as wide, but it has the occipital carina distinct medio-dorsally, the mesoscutum and mesopleuron (except for the precoxal sulcus) smooth, the first tergite slender, the hypopygium of ♀ yellowish, contrasting with the remainder of the meta-

soma, and the antenna of ♀ elongate. The new species shares with the Holarctic *P. relictus* (Ruthe, 1856) the reduced occipital carina but *P. relictus* has the basal cell of the fore wing largely glabrous or sparsely setose, the antenna with 17-20 segments, the frons and the middle lobe of the mesoscutum punctulate and the hind femur of ♀ dark brown.

Description of holotype, ♀, length of body 3.2 mm, of fore wing 2.4 mm.

Head.— Antenna with 23 segments (but eighth segment deformed), length of third segment 1.3 times fourth segment, third, fourth and penultimate segments 2.7, 2.1 and 1.2 times their maximum width (figs 5, 7, 8); face evenly and densely finely punctate and convex; clypeus smooth; frons moderately punctate, interspaces about equal to diameter of punctures; frons with long and distinctly developed median carina, with some short curved carinae ventrally and some chevron-shaped carinae dorsally (fig. 4); vertex with some widely spaced medium-sized punctures; length of maxillary palp 0.6 times height of head, fifth (= apical) segment 2.1 times as long as fourth segment; length of posterior side of stemmaticum 1.7 times lateral side; OOL:diameter of posterior ocellus:POL = 8:5:7; in dorsal view length of eye 1.1 times temple; temples parallel-sided behind eyes and somewhat narrowed posteriorly; length of malar space 0.7 times basal width of mandible.

Mesosoma.— Length of mesosoma 1.3 times its height; side of pronotum largely coarsely vermiculate-rugose; precoxal sulcus coarsely cellulate-crenulate medially, but absent anteriorly and irregular posteriorly (fig. 3); remainder of mesopleuron with mixture of large to small punctures (fig. 3); pleural sulcus widely crenulate ventrally and much narrower so dorsally (fig. 3); mesosternal sulcus absent anteriorly and posteriorly, weakly crenulate; notauli distinctly cellulate-crenulate; middle lobe of mesoscutum rather densely and distinctly punctate and setose, lateral lobes smooth posteriorly and distinctly punctate anteriorly and normally shiny; scutellar sulcus with 3 strong carinae; scutellum with few punctures and with distinct medio-posterior depression, semicircular; propodeum completely reticulate-rugose.

Wings.— Fore wing: basal and subbasal cell moderately densely setose; vein 1-R1 complete, its length 0.47 times length of pterostigma and 1.1 times width of pterostigma (fig. 2); vein r short and wide and distinctly behind middle of pterostigma (fig. 2); r:SR1+3-SR:2-SR = 2:30:16; vein m-cu slightly postfurcal; 1-CU1:2-CU1 = 1:9. Hind wing: 1-M:1r-m:2-SC+R = 9:15:4.

Legs.— Hind coxa smooth; length of femur, tibia and basitarsus of hind leg 3.5, 10.0 and 7.0 times thier maximum width; hind tibial spurs 0.4 times as long as hind basitarsus; second-fourth segments of fore tarsus comparatively slender and telotarsus distinctly enlarged (fig. 6).

Metasoma.— First tergite robust (fig. 9), open ventrally, distinctly widened posteriorly, its length 1.5 times its apical width and its surface coarsely longitudinally striate, but medio-posteriorly irregularly sculptured (fig. 9); spiracle of first tergite near middle of tergite; ovipositor sheath just visible, hardly protruding.

Colour.— Dark brown; head and metasoma after first tergite slightly less darkened than mesosoma, and clypeus orange-brown; apical half of antenna and dorsal apical half of hind tibia darkened; remainder of antenna and of legs, and palpi pale yellowish; pterostigma dark brown with pale spot basally.

Variation.- Males have the shape of the head similar to that of females, without

bulging temples, antenna with 24(1) or 25(1) segments, hind tibia weakly or not infuscate dorsally and frons weaker punctulate than face of ♀-holotype, first metasomal tergite largely irregularly coarsely sculptured and more slender than of holotype, its length 1.7 times its apical width and vein 1-R1 of fore wing equal to width of pterostigma.

Key to *Peristenus* species reared from *Lygus rugulipennis* in Europe

(based on a MS-key by the second author; the included species are characterized by a long median carina of frons and having the occipital carina nearly always widely interrupted medio-dorsally)

1. Basal cell of fore wing sparsely setose or largely glabrous, distinctly less setose than first subdiscal cell; hind femur of ♀ largely dark brown; frons and middle lobe of mesocutum sparsely punctulate, largely smooth; antennal segments of ♀ 17-21 (♂ up to 25); ex *Lygus rugulipennis*, *Adelphocoris* and *Polymerus* on arable plants ..... ***P. relictus*** (Ruthe, 1856)
   Notes.— *P. stygicus* Loan, 1973, **syn. nov.** Introduced in the U.S.A. for biocontrol of *Lygus* species. Males have the clypeus narrower than the minimum width of face and the frons less punctulate antero-laterally.
- Basal cell of fore wing normally setose and similarly setose as first subdiscal cell; hind femur of ♀ pale yellowish to brown; frons and middle lobe of mesocutum distinctly punctate, and at least partly largely sculptured; antennal segments of ♀♂ 19-25 2
2. Face dark brown, distinctly bulging, and comparatively short setose (fig. 10); minimum width of face of ♀ about 1.5 times height of face (fig. 4); pterostigma and marginal cell of fore wing less robust (fig. 2); third antennal segment of ♀ more robust (fig. 7); temples completely dark brown; occipital carina joining hypostomal carina ventrally; ex *Lygus rugulipennis* on cereals in summer ..... ***P. varisae*** van Achterberg, spec. nov.
- Face at least partly yellowish, hardly or not bulging, and comparatively long setose; minimum width of face of ♀ 1.1-1.3 times height of face; pterostigma and marginal cell of fore wing more robust; third antennal segment of ♀ less robust; temples at least partly dark reddish; occipital carina often remain separated from hypostomal carina ventrally 3
3. Vein 1-R1 of fore wing 0.5-0.8 times width of pterostigma; head of ♂ rather bulging behind eyes and temple strongly convex, comparatively wide compared to small eye, and temples (as more or less mesoscutum) yellowish; vein 2-SR1 of fore wing more or less straight, and angle between veins 2-SR and SR1 basally much more than 90°; antennal segments of ♀♂ (20-)22-25; ex *Lygus rugulipennis* on cereals, with summer diapause ..... ***P. rubricollis*** (Thomson, 1892)
   Note.— Possibly a synonym of *Perilitus brevicornis* Herrich-Schäffer, 1838, because of the short vein 1-R1 of fore wing and the robust, rather bulging reddish head in dorsal view.
- Vein 1-R1 of fore wing 0.8-1.0 times width of pterostigma; head of ♂ not or slightly bulging behind eyes and temple moderately convex, comparatively narrower compared to medium-sized eye, temples (as mesoscutum) largely or completely dark (reddish-)brown; vein 2-SR1 of fore wing slightly curved (rarely straight), and angle between veins 2-SR and SR1 basally often about than 90°; antennal segments of ♀ 19-20, of ♂ up to 21 (type-series); ex *Adelphocoris linolatus* (Goeze) on

alfalfa; with two generations per year: spring generation in *Lygus rugulipennis* on cereals, second summer generation in *Lygus* on potatoes and beets .... ***P. digoneutis*** Loan, 1973

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