



Mirid bugs as an emerging threat to bottle gourd cultivation: Dynamics and management

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ABSTRACT

First record of concurrent occurrence of mirid bugs *Nesidiocoris cruentatus* (Ballard) and *Metacanthus pulchellus* Dallas as serious and emerging pests of bottle gourd from Varanasi, Uttar Pradesh, India is reported hereunder. Studies carried out during 2016-17 indicated that about 70-80% fruits and 30% shoots were damaged by these bugs. Infested leaves showed, minute puncture spots with yellow hallows. Damage was more prominent on young fruits with typical brown puncture spots on the rind with sap oozing out were the characteristic symptoms of these sucking pests. Affected fruits therefore had significantly reduced market value. Studies on species composition of two mirid bugs showed that *N. cruentatus* was dominant species contributing overall 68.63% of the mirid bug population infesting bottle gourd followed by *M. pulchellus* (31.37%). *N. cruentatus* exhibited a strong diurnal activity as its incidence increased during day time gradually from 10 am onwards, with peak occurrence at 1 pm (3.88 bugs/fruit). Amongst the biopesticides evaluated under laboratory conditions, neem oil (1%) was found most promising with lowest median lethal time (50.31 h) followed by *Beauveria bassiana* (52.26 h) and *Lecanicillium lecanii* (56.59 h), whereas Flonicamid 50% WG and Spiromesifen 22.9% SC were most promising chemicals under field and laboratory conditions.

Keywords: Bionomics, Damage symptoms, Entomopathogens, Feeding preference, Insecticides

Lagenaria siceraria (Molina) Standley (Bottle gourd), a very popular cucurbitaceous vegetable crop, is grown all through out the year almost across the India. It forms a rich source of vitamins, iron, choline and minerals. It is easily digestible and good for diabetes, insomnia, urinary infection, ulcers, constipation etc. (Parle and Kaur 2011). This crop is attacked by a large number of insect pests throughout its growth period. Apart from occurrence of its regular insect pests, viz. fruit fly and red pumpkin beetle, recently, heavy, incidence of mirid bugs (Hemiptera: Miridae) occurred on tender leaves and young fruits of bottle gourd in many parts of Uttar Pradesh, India. In the beginning, minute puncture spots with yellow hallows were observed on tender leaves. The damage was more prominent in young fruits. Brown puncture spots on the rind with sap oozing out from the tender fruits is the characteristic symptoms of these sucking pests. Several local farmers visiting the institute also reported the same problem. The damaged fruits often failed to fetch a good market price.

The two mirid bugs were taxonomically identified as *Nesidiocoris cruentatus* (Ballard) and *Metacanthus pulchellus* Dallas. Recently, occurrence of *N. cruentatus* on bottle gourd was reported from Bengaluru, Karnataka, India (Ranganath *et al.* 2015). Earlier, *M. pulchellus* recorded as a pest of bottle gourd from eastern part of the India (Dhiman 1991). But present studies revealed the concurrent occurrence of both these mirid bug species on bottle gourd. So far, there is no information about the concurrent occurrence of both the mirid bugs on bottle gourd. This prompted to conduct a detailed study to know the pest dynamics, nature of damage, distribution among plant canopy, feeding preference, influence of cultivation technique so as to devise suitable control measures for this nefarious pest as practically no literature is available about these mirids. Moreover, the present study will also help to identify the most suitable bioagents(s) and chemical(s) and their most appropriate time and place of application for its ecofriendly management in bottle gourd.

MATERIALS AND METHODS

Studies on morphology, species composition, seasonal incidence, feeding behavior, plant part preference, diurnal activity, influence of cultivation practices, and suitable bioagents and chemical insecticides were carried out during summer (March to June), rainy (July to October) and winter (November to February) 2016-2017 at the ICAR-Indian Institute of Vegetable Research (IIVR), Varanasi (82°52'

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E longitude and 25°12' N latitude), Uttar Pradesh, India.

Biosystematics and species composition of the sucking pests: Specimens of adult bugs collected (preserved in 90% alcohol) were sent to the National Pusa Collection, Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi, for their taxonomic identification and got identified. Two species of the mirid bug(s) on bottle gourd and their concurrent occurrence were determined at the experimental farm throughout the bottle gourd growing periods grown on raised bed and trailing systems from last week of April (17th standard meteorological week [SMW]) to the last week of November (47th SMW) at weekly collections with a sweep net. Insect samples were brought to the biocontrol laboratory of ICAR-IIVR, Varanasi. Two species of mirid bugs were separated by their distinct morphological characters and species composition (%) over the period was computed by the following formula

$$\text{Composition (\%)} \\ \text{of } N. \text{ cruentatus} \\ \text{amongst the mirid} \\ \text{bugs} = \frac{\text{Number of } N. \text{ cruentatus} \\ \text{collected}}{\text{Total number of mirid bugs} \\ \text{collected}} \times 100$$

Similarly, share of *M. pulchellus* population amongst the mirid bugs infesting bottle gourd was also calculated and expressed in per cent.

Nature and severity of damage: To identify the feeding behavior and damage symptoms of the mirid bugs, a bottle cage was prepared. The main component of the bottle cage was a round shaped transparent plastic bottle, 2-liter capacity, on which 2 opposite sides were transversely cut and broad end were opened. The entire plastic bottle was covered with a white colored nylon net (200 mesh). Ten tender uninfested bottle gourd fruits (up to 10 days from hand made cross fertilization) were placed inside the bottle cage singly and the broad end tied with a rubber band. Twenty 1-2 day-old adults of males and females (1:1 ratio) of *N. cruentatus* and *M. pulchellus* were released separately in each cage. Another set of 10 fruits, of the same stage, were placed in bottle cages with no insects as the control. Seven days after release, fruits were removed from cages and observation was taken on feeding habit(s) and visible damage symptoms, if any.

Studies on diurnal activity: To study diurnal activity of the mirid bugs, number of adult bugs present on 50 randomly selected tender fruits (up to 10 days from hand made cross fertilization) were counted once in a week at hourly intervals from 6.00 am to 6.00 pm, which coincided with sunrise and sunset during September and October. A total of 650 fruits were sampled daily once in a week. Data on number of bugs(s) on fruit at a specific time of day were pooled for different weeks and months and expressed as average number of bugs(s) per fruit.

Studies on distribution of the bugs within the plant and feeding preferences: To identify distribution of bugs within plants, weekly observations were taken on apical buds, tender fruits (up to 10 days from fertilization), tender leaves adjacent (up to 10 cm) to the apical shoots, young

leaves 1 m from the apical shoot, mature green leaves 2 m from the apical shoot, and male and female flowers. Since bottle gourd is grown almost throughout the year in summer, rainy and winter in the region, data were recorded separately for all seasons.

To ascertain feeding preference of the bugs, several apical buds, tender fruits (up to 10 days from fertilization), young leaves, and male and female flowers were harvested. All plant parts were subjected to a 6 armed olfactometer assay with both mirid species. The olfactometer had a central arena (18.7 cm dia × 5.1 cm depth) and 6 equidistant arms (2.5 cm dia and 9.5 cm length). Fifty adult bugs, starved for 6 h, were introduced in the middle of the arena. After 3 h, numbers of bugs alighting on each plant part, and remaining in the central arena, i.e. box were counted. The experiment was replicated thrice and feeding preference of bugs was determined and expressed in per cent.

Influence of cultivation technique on abundance of mirid bugs: Raised bed and trailing systems of cultivation are commonly used for bottle gourd. In raised bed system, ridges (10 m × 3 m) were made and bottle gourd established from seed. For the trailing system, a bamboo based netting system (5 m × 4 m) was constructed and plants grown on it by creeping the nets. An isolation distance of 50 m was maintained between two cultivation systems. A total of 15 ridges and temporary nets were prepared. Application of inorganic fertilizer (N80:P60:K60) and cow manure @ 15 t/ha, irrigation before sowing seed and thereafter once weekly, and manual weeding were done. No pesticides were applied. Numbers of ired bugs were recorded weekly on shoots (up to 10 cm) and fruits (up to 10 days from hand made cross fertilization) of bottle gourds in both cultivation systems for suitability regarding pest incidence.

Bioefficacy of entomopathogens, botanicals and chemical insecticides : Talc based formulations of the EPF, viz. *Beauveria bassiana* IIVR strain (1×10¹⁰ cfu/g), *Metarhizium anisopliae* IIVR strain (1×10¹⁰ cfu/g) and *Lecanicillium (=Verticillium) lecanii* (2×10⁸ cfu/g) were used for the experiments. Neem oil (1%) was prepared by dissolving in water containing Triton X-100 as an emulsifier. All EPF at their recommended doses (5 g/L of water) were applied individually through a Potter's tower at 340 g/cm² pressure. The entomopathogens and neem oil (1%) were mixed at a 1:1 ratio and 1 mL of mixes applied under a Potter's tower. Tender bottle gourd fruits were provided to the treated insects and kept at 27±1°C and 70±5% RH. Twenty adult insects comprised a replication and 3 replications were maintained for each treatment. For assessment of toxicity, mortality counts were taken 12 h intervals and continued for 192 h after treatment (Halder et al. 2013). The median lethal time (LT₅₀) for EPF alone and their combination with neem oil with 1:1 ratio were calculated to determine compatibility and synergistic action, if any.

Eight insecticides, including conventional, and biorationale molecules of different groups and modes of action, were evaluated under laboratory conditions against

adult *N. cruentatus* at their recommended doses. Field collected adults seasoned under laboratory condition for 6 h were used for bioassay tests. Twenty adults were kept in a Petri dish and treated separately with 1 mL solution of each insecticide at indicated doses in Table 4 under the Potter’s tower. Treated Petri dishes containing test insects were air dried. Mortalities were counted 24 and 48 h after treatment and corrected percent mortality computed according to Abbott (1925) for each insecticide/treatment. Three replications were used for each treatment, including an untreated control.

Bioefficacy of the eight test insecticides were also evaluated under field conditions. Bottle gourd seeds, cv. Kashi Ganga, were sown during the second half of June in a plot size of 6 × 5 m. Recommended cultural methods for the crop were followed except any plant protection measures. Test insecticides were prepared using water just before application with a knapsack power sprayer. Populations of *N. cruentatus* and *M. pulchellus* were counted on 3 apical shoots and tender fruits from 5 randomly selected plants per plot, before and at 3, 7 or 10 days after each application. The percentage reduction (PR) of the pest over the untreated control was calculated as $PR = [(control\ count - treatment\ count/control\ count) \times 100]$ for each treatment following each spray. Treatment-wise marketable bottle gourd fruit yields were recorded at each picking and were pooled and expressed in ones/ha.

Data analysis: Distribution of bugs within plants was analyzed by cropping seasons and plant parts. Data were subjected to ANOVA. Data on population of mirid bugs after insecticide application were square root transformed. Mortality data were corrected following Abbott (1925) and

Probit analysis (Finney1971) done in SAS to calculating LT_{50} .

RESULTS AND DISCUSSION

Biosystematics and species composition of the sucking pests: Insects collected were identified as *Nesidiocoris cruentatus* (Ballard) and *Metacanthus pulchellus* Dallas (Hemiptera:Miridae). Both *N. cruentatus* and *M. pulchellus* occurred on bottle gourd concomitantly almost throughout the cropping period, except during the first half of August when only the former species was recorded (Fig 1). The *N. cruentatus* was dominant contributing most (68.63%) of the mirid bug population infesting bottle gourd. Most of the members of the family Miridae are predaceous except a few phytophagous (Hedo and Urbaneja 2015). In present study, two species of mirid bugs namely *N. cruentatus* and *M. pulchellus* were observed as emerging bottle gourd pests infesting north and eastern part of the country. Although the incidences of *N. cruentatus* as a sucking pest of bottle gourd has been reported earlier from the southern part of India (Ranganath *et al.* 2015) but the concurrent occurrence of both the mirid bug species is being reported for the first time from India. Moreover, the population of *N. cruentatus* out numbered the latter species.

Nature and severity of damage: The bugs are sap suckers on apical buds, young fruits, young leaves and flowers of bottle gourd. Nymphs and adults of both species feed by inserting their stylets. Due to their feeding, whitish sap oozes which later turned to a brownish hard encrustation on the fruit surface. Affected fruits had numerous brown irregular markings on the rind. The mirid bugs made 18–67 puncture spots on a single fruit, average 49.6 ± 4.12 spots

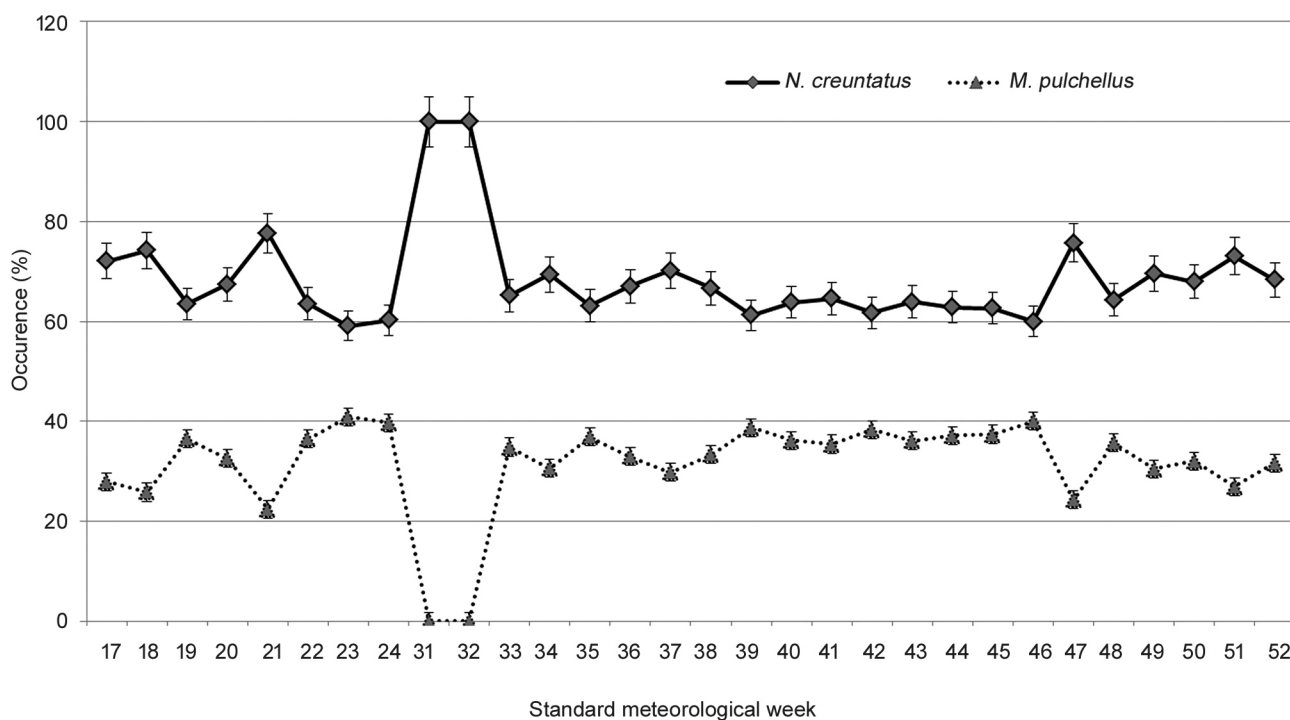


Fig 1 Seasonal incidence and species composition of mirid bugs on bottle gourd.

Table 1 Bio-efficacy of entomopathogens alone, and in combination with neem oil (1:1), against adults of *N. cruentatus*

Biopesticide	Heterogeneity		Regression equation (Y=)	LT ₅₀ (hr)	Fiducial Limit
	df	χ^2			
<i>M. anisopliae</i>	6	2.029	31.30X-0.605	61.81	76.06-56.22
<i>B. bassiana</i>	7	1.904	32.02X-0.502	52.26	62.96-43.48
<i>L. lecanii</i>	5	2.123	4.058X-2.112	56.59	66.16-48.11
Neem oil	6	0.566	2.369X-0.967	50.31	64.26-39.39
<i>M. anisopliae</i> + Neem oil	5	3.186	4.852X-3.026	45.10	51.78-39.28
<i>B. bassiana</i> + Neem oil	5	3.286	3.869X-1.339	43.49	51.70-36.59
<i>L. lecanii</i> + Neem oil	5	3.371	4.104X-1.656	41.85	49.71-35.24

per fruit during November–December, 2016. When released separately under caged conditions both mirid species caused identical damage symptoms. Under field conditions about 70–80% fruits and up to 30% shoots were infested by these mirid bugs during the winter season.

Studies on diurnal activity: Since, *N. cruentatus* was the dominant species and occurred almost throughout the year over *M. pulchellus* and cause major damage to bottle gourd in the region so *N. cruentatus* was taken for its diurnal activity study. *N. cruentatus* exhibited strong diurnal activity with incidence increasing gradually from 10 am, with peak activity at 1 pm (an average of 3.88 bugs/fruit) and thereafter decreasing from 2 pm onwards and at 6 pm only a few bugs (0.87 adults/fruit) were present. Information generated on the active period of mirid bug during the day would help in scheduling control measures. Application of suitable systemic insecticide should be scheduled during morning hours. For application of biopesticides, preference should be given at evening hours as bright sunlight accompanied with high temperature may degrade efficacy.

Distribution of the bugs within the plant and its feeding preference: The highest number of bugs were observed on apical buds in all the three growing seasons. For *N. cruentatus* more number of bugs were found on apical buds during rainy and winter seasons followed by tender leaves adjacent to the apical shoots, male flowers and tender fruits; number of bugs were similar on apical buds and tender leaves adjacent to the apical shoots during summer. In olfactometer study, the highest number (26.39%) of *N. cruentatus* were attracted towards apical buds followed by young leaves (16.67%) and tender fruits (15.28%) then male flowers (13.89%) and female flowers (12.50%). For *M. pulchellus* the strongest orientation (25.50%) was towards apical buds followed by young leaves (18.25%) and male flowers (14.75%). Apical buds, tender leaves adjacent apical shoots, flowers and tender fruits should be treated to manage the insects. The most bugs occurred during rainy season followed by summer and winter seasons. Temperature range of 20–28°C has been reported to be the most suitable temperature zone for insect survival, growth and reproduction. Mirid bugs exposed to the optimum temperature during the rainy season likely accounts for their

higher abundance. Higher and lower temperature prevailed during summer and winter seasons adversely affected the population of *N. cruentatus* (Halder et al. 2017).

Influence of cultivation techniques on abundance of mirid bugs: System of cultivations and plant parts together affected abundance of mirid bugs. The trailing system of cultivation harbored more mirid bugs. Significantly the highest number of bugs per tender shoot (7.2) was recorded in the bottle gourd when grown in trailing system than the raised bed system (1.35). A similar trend was also observed for the young fruits. Higher number of bugs (5.7) per fruit was recorded in bottle gourd when grown in trailing system compared to the conventional raised bed system (3.45). Both field and olfactometer studies revealed that *N. cruentatus* attracted maximum towards tender plant parts, apical buds followed by young leaves and tender fruits indicating more preference towards terminal plant parts. Thus the information generated under present study would help in diverting spray

Table 2 Effect of insecticides against bottle gourd mirid bugs under field conditions

Treatment	Dose (g a.i./ha)	Mean number of bugs per fruit		Marketable fruit yield (t/ha)
		PTC ^a	Mean PR	
Diafenthurion 50% WP	300	6.6	67.67	20.4 ^{cd}
Spiromesifen 22.9% SC	100	6.8	85.92	29.5 ^a
Flonicamid 50% WG	75	6.6	86.30	29.1 ^a
Flubendamide 39.35% SC	100	7.4	70.23	26.5 ^b
Imidacloprid 17.8% SL	35	8.6	69.92	21.6 ^{bc}
Thiamethoxam 25% WG	50	7.2	75.35	22.2 ^c
Dimethoate 30% EC	200	7.8	57.65	19.1 ^d
Acetamiprid 20% SP	15	6.2	78.90	23.8 ^c
Control	--	7.9	--	15.7 ^e

^aPTC = Pre-Treatment Count, PR = Percent reduction over control

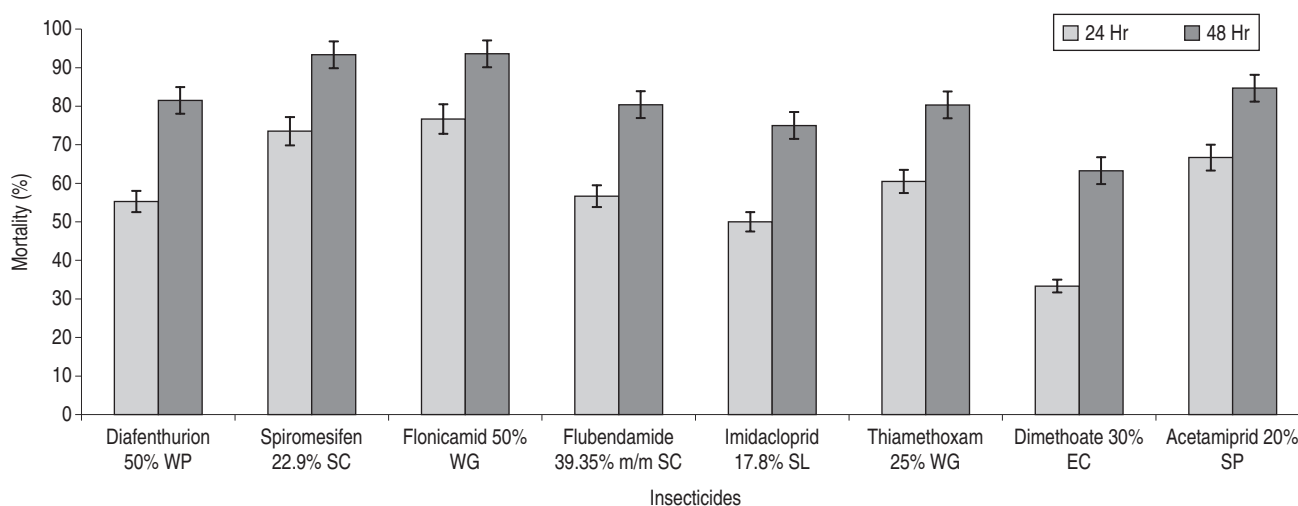


Fig 2 Bioefficacy of insecticides causing mortality in *N. cruentatus* under laboratory conditions.

towards terminal portion of the plants rather covering the whole plant for the management of mirid bugs. According to Shrivastava (1991) maximum congregation of mirid bug *N. tenuis* was on apical shoots of bottle gourd. Cultivation method influenced mirid bug incidence as evident from comparatively higher population on shoots and fruits in trailing system compared to flat bed system. Shoots and fruit in the trailing system were more prone to attack due to being more exposed and easily accessible to mirid bugs than raised bed cultivation where some part(s), or whole fruit, were covered by spreading leaves.

Bioefficacy of entomopathogens, botanicals and insecticides on mirid bugs: The biopesticides, neem oil had the lowest median lethal time (LT_{50} =50.31 h). Of the EPF, *B. bassiana* was the most effective (52.26 h) followed by *L. lecanii* (56.59 h). When each entomopathogenic fungi was mixed with neem oil at 1:1 ratio and applied at half of their recommended doses, *L. lecanii* and neem oil had the highest compatibility and synergistic activity against adults of *N. cruentatus* with the lowest median lethal time of 41.85 h (Table 1). The *L. lecanii* and *B. bassiana* were found promising against the mirid bugs.

Amongst the eight synthetic insecticides tested, two insecticides namely Flonicamid 50% WG and Spiromesifen 22.9% SC caused 76.67, 73.52 and 93.59, 93.33% mortality of *N. cruentatus* 24 and 48 h after treatment, respectively, under laboratory conditions where as Dimethoate 30% EC was found least effective (Fig 2). Same trend was also observed in field conditions. Flonicamid and Spiromesifen were the most promising chemicals registering 86.30 and 85.92% bugs reduction over control. Maximum marketable fruit yield (29.5 t/ha) was recorded from the plants treated with Spiromesifen followed by Flonicamid (29.1 t/ha); the lowest yield (15.7 t/ha) was obtained from the untreated control (Table 2). Compatibility of neem with major EPF has been reported (Halder *et al.* 2017). The present study confirmed compatibility of neem oil and EPF at 1:1 ratio and these could be a better biorational option for integration in

an IPM program. Among synthetic insecticides, the newer molecules Flonicamid and Spiromesifen were efficacious in reducing mirid bug populations in both laboratory and field. All the newer insecticides with diverse mode of action were more effective compared to the conventional organophosphate insecticide Dimethoate 30% EC.

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