Entomology

Diversity and seasonal abundance of harmful and beneficial true bugs (Hemiptera: Heteroptera) in Bt cotton

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Abstract

Objectives: To document the diversity and relative abundance of harmful and beneficial true bugs and characterize their seasonal abundance and relationship with major weather parameters on unsprayed Bt cotton under the agro-climatic conditions of Marathwada, Maharashtra.

Methods: A field investigation was conducted during Kharif 2025-26 at the Experimental Farm, Department of Entomology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, in unsprayed Rasi Swift BG-II (RCH-971 BG II) cotton. Diversity and seasonal abundance were assessed in two separate observation plots using five plants in each of four quadrats per plot; diversity was recorded fortnightly and seasonal abundance weekly. Pearson correlation coefficients were calculated between weekly bug abundance and weather parameters.

Results: Ten true-bug taxa belonging to six families were recorded. Of 1,689 individuals, Dysdercus cingulatus was most abundant (38.24%), followed by Oxycarenus hyalinipennis (23.68%); together they constituted 61.92% of the assemblage. Phytophagous taxa accounted for 80.46%, entomophagous taxa for 11.19% and the zoophytophagous Campylomma livida for 8.34%. Hill species richness, Margalef richness, Menhinick richness, Shannon-Wiener diversity, Pielou evenness and Simpson dominance were 10, 1.211, 0.243, 1.761, 0.765 and 0.229, respectively. Dysdercus cingulatus peaked at 13.75 bugs per plant in the 48th standard meteorological week, whereas O. hyalinipennis peaked at 15.75 bugs per plant in the 50th week. Late-season seed bugs showed significant negative associations with several weather variables, while N. viridula, Eocanthecona furcellata and C. livida were positively correlated with maximum temperature.

Conclusions: The true-bug community showed clear crop-stage-dependent succession. Monitoring should be intensified from boll opening onward for D. cingulatus and O. hyalinipennis while conserving beneficial heteropterans present earlier in the crop cycle.

Keywords: Bt cotton, Heteroptera, True-bug diversity, Seasonal abundance, Cotton seed bugs, Natural enemies

Introduction

Cotton (*Gossypium hirsutum* L.) is a major fibre and cash crop of India and supports a large production, processing and textile economy. Insect pests remain an important biological constraint to cotton production, but the pest complex has changed substantially following widespread adoption of Bt cotton. Bt technology primarily targets lepidopteran bollworms; consequently, sucking insects and other non-target arthropods may assume greater relative importance where broad-spectrum insecticide use is reduced [1, 2].

True bugs (Hemiptera: Heteroptera) are a particularly heterogeneous component of the cotton fauna because the group includes phytophagous pests, zoophytophagous species and obligate predators. Plant-feeding heteropterans damage reproductive structures and developing seeds with piercing-sucking mouthparts, whereas predatory taxa such as Eocanthecona and Geocoris contribute to natural pest suppression [3-5]. The coexistence of harmful and beneficial taxa means that management decisions based only on total bug abundance can obscure important differences in ecological function.

Changes in the heteropteran complex of Bt cotton have been documented in several regions. Mirid bugs have increased in importance in some Bt cotton systems, and both pest and beneficial arthropod populations vary markedly with crop stage, host availability and weather [6-9]. *Cotton seed bugs such as Dysdercus cingulatus and Oxycarenus hyalinipennis are especially associated with late reproductive stages and opened bolls, while stink bugs and mirids may be more prominent during flowering and boll development.*

Information integrating species diversity, trophic composition, seasonal succession and weather associations of true bugs is limited for *Bt* cotton under the agro-climatic conditions of Marathwada, Maharashtra. The present study therefore aimed (i) to document the diversity and relative abundance of harmful and beneficial true bugs on unsprayed *Bt* cotton and (ii) to characterize their seasonal abundance and relationship with major weather parameters.

Materials and Methods

Experimental site and crop

The investigation was conducted during *Kharif* 2025-26 at the Experimental Farm of the Department of Entomology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra (19°14′ N, 76°46′ E; 424.84 m above mean sea level). The field consisted of medium black cotton soil. *Bt* cotton hybrid Rasi Swift BG-II (RCH-971 BG II) was sown on 7 July 2025 at 90 × 30 cm spacing. Two separate 20 × 20 m observation plots were established, one for diversity assessment and the other for seasonal-abundance assessment. Each plot was divided into four 10 × 10 m quadrats. Recommended agronomic practices were followed, but no plant-protection treatment was applied in either observation plot.

Sampling and identification

Border plants were avoided. In each observation plot, five plants were randomly selected from each of the four quadrats, giving 20 observation plants per plot. Thus, the diversity and seasonal-abundance assessments were based on separate sets of 20 plants. Nymphs and adults of true bugs present on the selected plants were counted. Diversity observations were recorded at fortnightly intervals from the designated diversity plot, whereas seasonal-abundance observations were recorded weekly from the separate seasonal-abundance plot. Specimens were collected when necessary and identified from diagnostic morphological characters using standard taxonomic literature. Taxa were classified as phytophagous, zoophytophagous or entomophagous according to their predominant feeding habit.

Diversity analysis

Species composition and abundance were summarized for the complete diversity sample. Relative abundance was calculated as the percentage contribution of each taxon to the total number of individuals. Community diversity was characterized using Hill's species richness (N0 = S), Margalef richness index (R1), Menhinick richness index (R2), Shannon-Wiener diversity index (H′), Simpson's dominance index (λ) and Pielou's evenness index (E), following the conventions used by Ambrose (2004).

Seasonal abundance and weather relationship

Weekly mean populations were expressed as nymphs plus adults per plant and arranged by standard meteorological week (SMW). Seasonal patterns were interpreted with reference to crop phenology. Pearson's correlation coefficients were calculated between the weekly abundance of each taxon and maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall and wind speed. Statistical significance was assessed at the 5% level. Correlations were interpreted as seasonal associations rather than evidence of direct causation because crop phenology and weather changed concurrently.

Results and Discussion

True-bug composition and trophic structure

Ten true-bug taxa belonging to six families were recorded (Table 1). Miridae was the most taxonomically represented family with three taxa, followed by Lygaeidae and Pentatomidae with two taxa each. Pyrrhocoridae, Geocoridae and Reduviidae were represented by one taxon each. Six taxa were phytophagous, three were entomophagous predators and Campylomma livida was zoophytophagous. This mixture of trophic guilds demonstrates that unsprayed Bt cotton supported both crop-feeding bugs and natural enemies. Comparable coexistence of pest and beneficial arthropods has been reported in Bt cotton systems, where reduced broad-spectrum insecticide pressure can favour conservation of natural enemies while also permitting secondary pests to become more conspicuous [1, 7, 8].

Table 1: True bugs recorded on *Bt* cotton during *Kharif* 2025-26

Family	Common name	Scientific name	Feeding habit
Pyrrhocoridae	Red cotton bug	*Dysdercus cingulatus (Fabricius)*	Phytophagous
Lygaeidae	Dusky cotton bug	*Oxycarenus hyalinipennis (Costa)*	Phytophagous
Lygaeidae	Seed bug	*Graptostethus servus Fabricius*	Phytophagous
Pentatomidae	Green stink bug	*Nezara viridula (Linnaeus)*	Phytophagous
Pentatomidae	Predatory stink bug	*Eocanthecona furcellata (Wolff)*	Entomophagous
Miridae	Dimple bug	*Campylomma livida (Reuter)*	Zoophytophagous
Miridae	Mirid bug	*Hyalopeplus lineifer (Walker)*	Phytophagous
Miridae	Grass bug	*Stenodema spp.*	Phytophagous
Geocoridae	Big-eyed bug	*Geocoris spp.*	Entomophagous
Reduviidae	Reduviid bug	*Sycanus falleni (Stål)*	Entomophagous

Relative abundance and diversity

A total of 1,689 individuals was recorded in the diversity observations (Table 2). *Dysdercus cingulatus* was the dominant taxon with 646 individuals (38.24%), followed by *Oxycarenus hyalinipennis* with 400 individuals (23.68%). Together, these two late-season cotton-associated species constituted 61.92% of all true bugs. *Nezara viridula* ranked third (10.59%), followed by *C. livida* (8.34%), *Hyalopeplus lineifer* (6.03%), *Geocoris spp.* (5.21%) and *Eocanthecona furcellata* (4.97%). *Graptostethus servus*, *Sycanus falleni* and *Stenodema spp.* each contributed about 1% or less. Numerically, phytophagous taxa accounted for 80.46% of individuals, entomophagous taxa for 11.19% and the zoophytophagous component for 8.34%.

Table 2: Relative abundance of true bugs on *Bt* cotton during *Kharif* 2025-26

Taxon	Jul	Aug	Sep	Oct	Nov	Dec	Total	RA (%)
D. cingulatus	0	0	0	80	245	321	646	38.24
O. hyalinipennis	0	0	0	10	105	285	400	23.68
G. servus	0	3	3	7	5	0	18	1.06
N. viridula	0	40	25	51	56	7	179	10.59
E. furcellata	0	25	6	36	15	2	84	4.97
C. livida	0	41	16	45	32	7	141	8.34
H. lineifer	1	11	5	42	41	2	102	6.03
Stenodema spp.	0	0	0	10	4	0	14	0.82
Geocoris spp.	1	9	12	22	28	16	88	5.21
S. falleni	0	0	0	9	3	5	17	1.0

Total individuals (N) = 1,689; RA = relative abundance

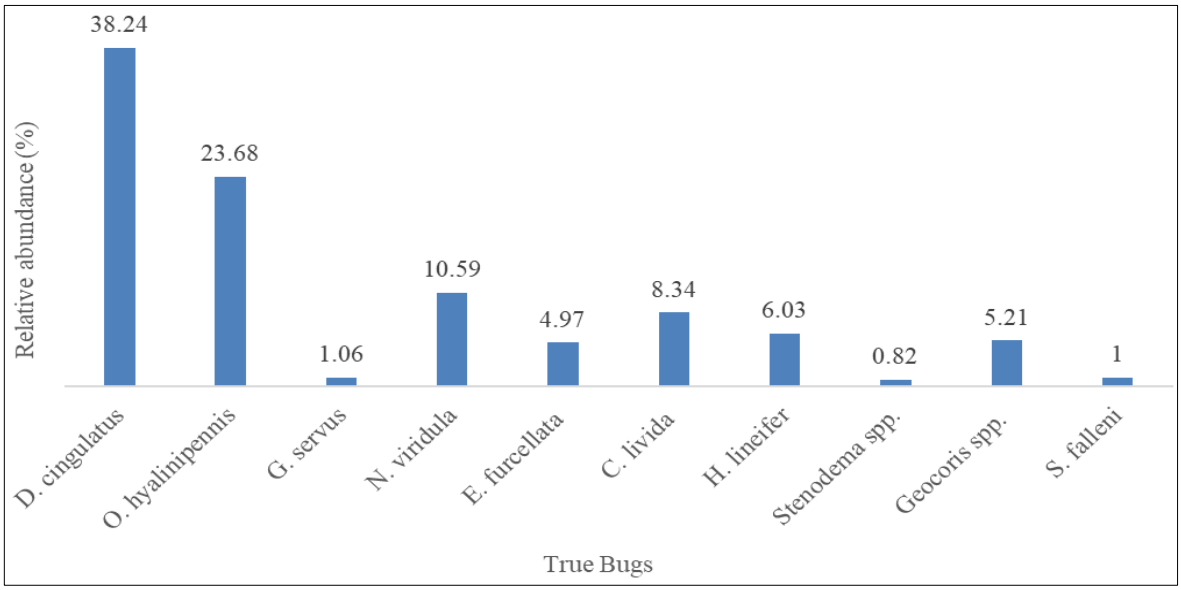


Fig 1: Relative abundance of true bugs recorded on Bt cotton during Kharif 2025–26

The assemblage contained 10 taxa (Hill's N0 = 10). Margalef and Menhinick richness indices were 1.211 and 0.243, respectively; Shannon-Wiener diversity was 1.761, Pielou evenness 0.765 and Simpson dominance 0.229 (Table 3). The combination of moderate evenness with a relatively low Simpson λ indicates that the community was heterogeneous but not evenly distributed, because D. cingulatus and O. hyalinipennis formed a pronounced dominance hierarchy. Studies from Indian cotton ecosystems similarly show that arthropod composition can be diverse while a small number of taxa account for much of the seasonal abundance [15, 14, 9].

Table 3: Diversity indices of the true-bug assemblage

Index	Value
Hill species richness (N_0)	10
Margalef richness (R_1)	1.211
Menhinick richness (R_2)	0.243
Shannon-Wiener diversity (H′)	1.761
Pielou evenness (E)	0.765
Simpson index (λ)	0.229

Seasonal abundance and succession

The true-bug complex showed a clear temporal succession rather than a synchronous increase of all taxa. Mirids, N. viridula and predatory heteropterans were most evident during flowering and boll development, whereas D. cingulatus and O. hyalinipennis became dominant during boll opening and the terminal crop period. This crop-stage dependence agrees with the broader evidence that cotton pest and natural-enemy communities shift with reproductive phenology and resource availability [6, 9].

Dysdercus cingulatus was absent from the 27th to 40th SMW and first appeared in the 41st SMW at 0.75 bug per plant. Its population increased sharply from late November and peaked at 13.75 bugs per plant in the 48th SMW (1-7 December). High densities persisted through the 49th and 50th SMW. The pattern closely resembles the late-season occurrence reported from Bt cotton in Karnataka and is biologically consistent with increasing availability of mature seed and opened bolls [8, 10].

Oxycarenus hyalinipennis appeared still later, first occurring in the 45th SMW at 0.75 bug per plant. Its population increased rapidly through December and reached the highest seasonal density recorded for any taxon, 15.75 bugs per plant, in the 50th SMW (15-21 December). Earlier work on Oxycarenus in cotton likewise associates population build-up with seed availability and boll opening, although the exact peak week varies with sowing date and regional climate [12, 13, 11].

Nezara viridula and C. livida each attained 3.75 bugs per plant

in the 44th SMW, while E. furcellata peaked earlier at 3.00 bugs per plant in the 42nd SMW. The remaining taxa occurred at lower or intermittent densities. The presence of E. furcellata, Geocoris spp. and S. falleni across parts of the season is agronomically relevant because these predatory Heteroptera form part of the natural-enemy complex that should be conserved in integrated pest management programmes [4].

Table 4: Major seasonal peaks of true bugs on Bt cotton

Taxon	Peak SMW	Period	Peak bugs per plant
D. cingulatus	48	1-7 Dec.	13.75
O. hyalinipennis	50	15-21 Dec.	15.75
N. viridula	44	3-9 Nov.	3.75
E. furcellata	42	20-26 Oct.	3.00
C. livida	44	3-9 Nov.	3.75

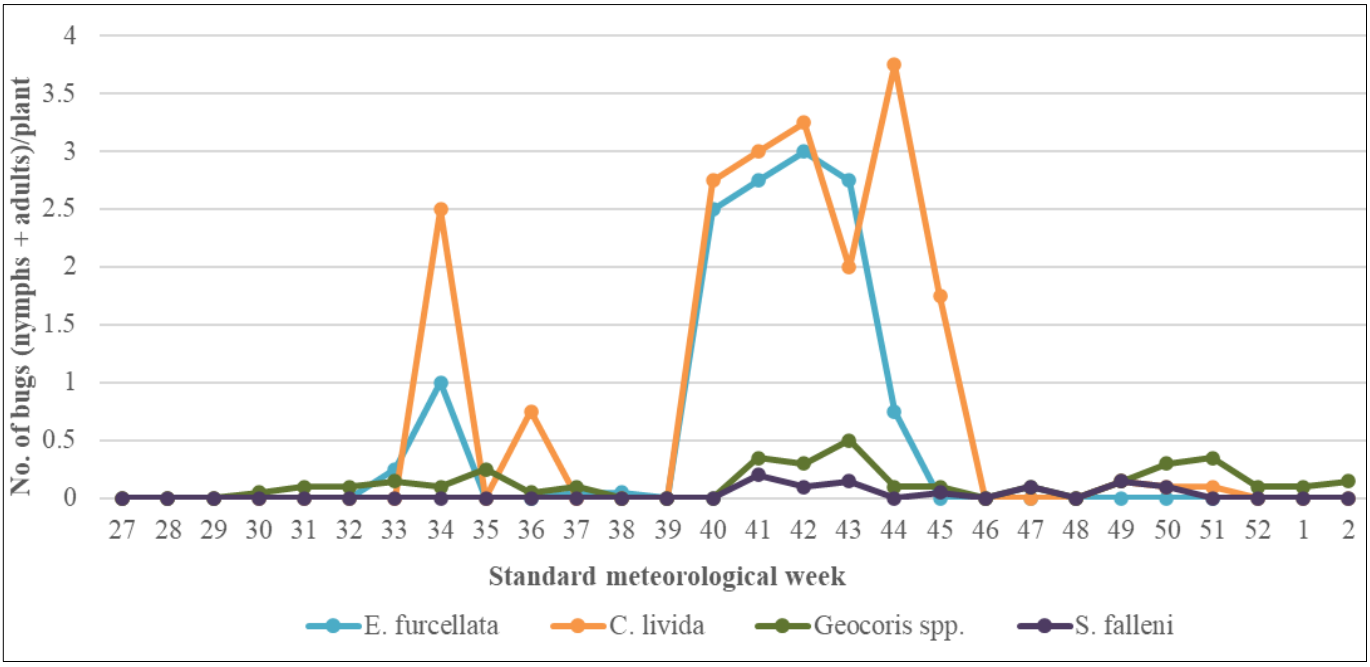


Fig 2: Seasonal abundance of harmful true bugs on Bt cotton during Kharif 2025-26

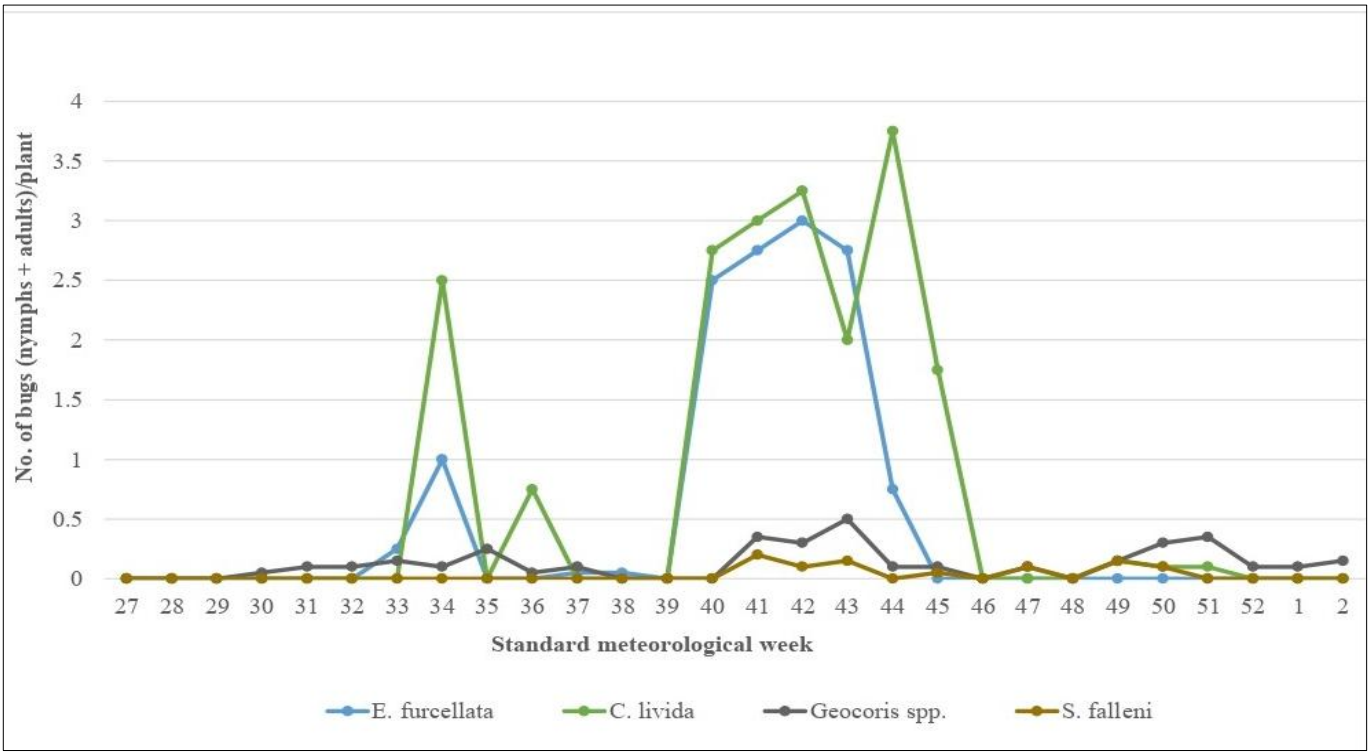


Fig 3: Seasonal abundance of beneficial true bugs on Bt cotton during Kharif 2025-26

Relationship with weather parameters

Correlation analysis revealed strong species-specific differences (Table 5). *D. cingulatus* showed significant negative correlations with maximum temperature (r = -0.415), minimum temperature (r = -0.846), evening relative humidity (r = -0.782), rainfall (r = -0.482) and wind speed (r = -0.578).

O. hyalinipennis showed the same overall pattern, with significant negative correlations with maximum temperature (r = -0.465), minimum temperature (r = -0.854), evening relative humidity (r = -0.707), rainfall (r = -0.416) and wind speed (r = -0.547). Their strongest negative associations were with minimum temperature and evening humidity. These coefficients reflect their late-season placement when temperature, rainfall and humidity were declining and opened bolls were becoming increasingly available; they should therefore not be interpreted as proof that low temperature alone caused population increase.

In contrast, *N. viridula* (r = 0.580), *E. furcellata* (r = 0.534) and *C. livida* (r = 0.548) showed significant positive correlations with maximum temperature. *G. servus, H. lineifer, Stenodema spp.* and *Geocoris spp.* showed no significant relationship with the weather variables considered, while *S. falleni* was significantly negatively correlated only with evening relative humidity (r = -0.403). The mixed responses reinforce the need to interpret weather effects in conjunction with crop phenology, prey availability and host-resource dynamics rather than expecting a uniform meteorological response across trophic guilds.

Table 5: Pearson correlation coefficients between weekly true-bug abundance and weather parameters

Taxon	T_{max}	T_{min}	RH-AM	RH-PM	Rainfall	Wind
D. cingulatus	-0.415*	-0.846*	-0.212	-0.782*	-0.482*	-0.578*
O. hyalinipennis	-0.465*	-0.854*	-0.214	-0.707*	-0.416*	-0.547*
G. servus	0.223	0.202	-0.002	0.099	-0.003	0.015
N. viridula	0.580*	0.270	-0.030	0.010	-0.192	0.003
E. furcellata	0.534*	0.239	0.033	-0.011	-0.108	0.011
C. livida	0.548*	0.235	-0.026	-0.016	-0.183	-0.004
H. lineifer	0.288	0.069	-0.115	-0.088	-0.043	-0.249
Stenodema spp.	0.278	-0.018	-0.240	-0.185	-0.110	-0.201
Geocoris spp.	0.031	-0.190	0.041	-0.237	-0.287	-0.177
S. falleni	0.289	-0.201	-0.146	-0.403*	-0.371	-0.252

* Significant at P = 0.05; T_{max}/T_{min} = maximum/minimum temperature; RH-AM/RH-PM = morning/evening relative humidity

Conclusion

Unsprayed *Bt* cotton at Parbhani supported a taxonomically and functionally diverse true-bug assemblage comprising 10 taxa from six families. The community was numerically dominated by the phytophagous *D. cingulatus* and *O. hyalinipennis,* which together contributed 61.92% of all individuals, although predatory *E. furcellata*, *Geocoris spp.* and *S. falleni* were also consistently represented. Seasonal succession was strongly crop-stage dependent: mirids, *N. viridula* and predators were associated mainly with flowering and boll development, whereas *D. cingulatus* and *O. hyalinipennis* became dominant during boll opening and crop maturity. Weather correlations largely mirrored this seasonal placement, particularly the negative associations of late-season seed bugs with temperature, evening humidity, rainfall and wind speed. Monitoring in *Bt* cotton should therefore be intensified from boll opening onward *for D. cingulatus* and *O. hyalinipennis*, while pest-management interventions should be selected to conserve beneficial heteropterans present earlier in the crop cycle.

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