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Seasonal flight activity and seasonal dynamics of biodiversity of sawflies in the Cserhát Mountains

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Haris, A.: *Seasonal flight activity and seasonal dynamics of biodiversity of sawflies of the Cserhát Mountains.*
Abstract: Seasonal flight activity and seasonal dynamics of biodiversity of sawflies of the Cserhát Mountains are analysed, dominance and biodiversity indices are given. Both of them are modelled by normal distribution which are verified by Shapiro-Wilk and Kolmogorov-Smirnov tests. Dominance diversity curve of assemblage of sawflies is also provided.

Keywords: Hymenoptera, Symphyta, Cserhát Mountains, Hungary, seasonal flight activity, seasonal dynamics of biodiversity, sawfly ecology

Introduction

The first checklist of sawflies from the Cserhát Mountains (Fig. 5) were presented by Haris (2021). In this paper, 573 specimens of 110 species were published. The presence of *Sterictiphora furcata* (Villers, 1789) confirmed and documented first time in the Carpathian Basin. Rare species are: *Empria hungarica* (Konow, 1895), *Aprosthema austriacum* (Konow, 1892), *Arge pleuritica* (Klug, 1834), *Monardis plana* (Klug, 1817), *Hoplocampa pectoralis* Thomson, 1871, *Pachynematus moerens* (Förster, 1854) and *Pristiphora abbreviata* (Hartig, 1837).

In this phase of the research, the seasonal flight activity and the seasonal dynamics of biodiversity are analysed.

In Hungary, seasonal activities of sawflies were studied at only few insect pests (like *Dolerus* spp., *Hoplocampa* spp., *Pachynematus* spp., *Athalia rosae* L.) (Haris 1994a, b, 1995, Száringer 1957, Nagy 1960) although their mathematical analyses were not performed.

Out of Hungary, only Roller (2006) studied the seasonal flight activity of sawflies of the sub-montane areas of the West Carpathians. He studied and analysed the total Symphyta group.

Material and methods

Standardisation of the sampling sites and collecting times

Average size of a sampling site was 35 000 sqm (3.5 ha). In each sampling sites, we spent 1.5 hour with collection in each day. During this 1.5 hour, approx. 900 net-sweepings were performed on 950-1100 m route inside the sampling sites. Grass-level, bush

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level and lower canopy level were swept. With this method, we successfully eliminated the high selectivity of the frequently applied Malaise trap method. In one days, 3-5 sites were investigated (generally, in one day the Eastern part and on the other day the Western part of the mountains). Minimum 2 days, we spent in each decades of the flying season with sawfly collection. During the intensive eruption of the sawflies density we spent more days (if the weather allowed, every days were spent with field-work). In this way, each decades were represented by average of minimum 2 days of collection, while decades of the intensive flying period is represented by the average of 5-7 days collections and the suppressed (sleeping) period of flight activity is represented by the average of 2-4 days collections. Frequent sampling in the spring flying season was very necessary to capture the rare species of the region for faunistic analysis.

In this way, during the 2021 collecting season, I spent 1 day with collecting in March, 13 days in April, 8 days in May, 5 days in June, 5 days in July and 4 days in August.

We had unique opportunity to investigate the flying dynamics of sawflies in extreme weather conditions. The spring of 2021, was one of the three coldest springs, in the 21st and 20th centuries and it was the coldest since 1987. Furthermore, the Cserhát Mountains is one of the northernmost and coldest region of Hungary. See the temperature charts of Hollókő (at Eastern Cserhát Mts.) for the most critical months of sawfly flying period: April and May (2020 and 2021 years).

Models for flying and biodiversity dynamics were tested by Kolmogorov-Smirnov test (NEDOREZOV 2014). Biodiversity indices were interpreted and applied following the works of DALY et al. 2018 and YOUNG 2017. Dominance diversity curve of sawflies and the curve fitting (mathematical model) follow the work of SOUTHWOOD 1984 and MÁJER 1994.

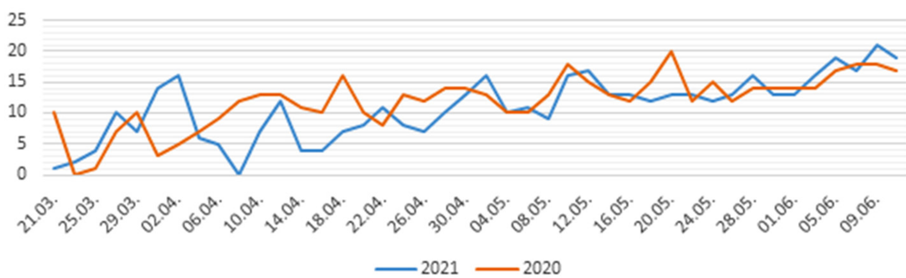

Fig. 1: Mean temperature in Hollókő in 2020 and 2021 during the main flying period of sawflies in Celsius

Frequency and rarity of species

RABINOWITZ (1981) established 7 categories according to geographical distribution, habitat specificity and local population size for the so called rarity of species. Her method was not applicable here, since with this method, most of the species would fall into DD (data deficient) category as they are indicated in ROLLER & HARIS 2008. Instead of this, the method of KOZÁR et al. (1992) for larger territories (like Carpathian Basin or Hungary) was applied where the natural history collections of the museums and the published faunistic data are the bases to categorise the species into rare, sporadic, frequent and common categories:

- rare species: max. 5 exemplars are captured and/or published in every 50 years in average (i.e. we have data on maximum of 15 exemplars from the last 150 years (see ROLLER & HARIS 2008);

Fig. 2: Map of Kutasó: Középső-hegy (Középső hill, former vineyards)

Fig. 3: Map of Nagylóc: Alsó-Zsúny

Fig. 4: Map of Penc: Obszervatórium (forest at Observatory)

Fig. 5: Cserhát landscape (photo: Haris)

Fig. 6: Sinkár lake at Csővár (photo: Haris)

- sporadic: max. 5 exemplars are captured and/or published in every 10 years in average (i.e. we have data on maximum of 75 exemplars from the last 150 years;
- frequent: we have data more than 75 exemplars from the last 150 years;
- common: these are approximately 10 species in the Carpathian Basin which occur regularly in the highest densities (some of them are insect pests).

List of sampling sites

Alsópetény: Bánki-völgy (Bánki valley): between 47°53'8.26"N, 19°13'50.50"E and 47°53'15.09"N, 19°13'56.40"E, altitude: 219-237 m.

Alsópetény: Cser-tó (Cser lake): between 47°52'7.97"N, 19°15'17.19"E and 47°52'6.68"N, 19°15'8.67"E, altitude: 215 m.

Alsótold: Nagy-Mező-hegy (Nagy-Mező hill): between 47°56'47.79"N, 19°35'29.85"E and 47°56'32.58"N, 19°35'32.87"E, altitude: 230-258 m.

Bánk: Száva-hegy (Száva hill):between 47°55'20.06"N, 19°12'52.27"E and 47°55'32.80"N, 19°12'43.31"E, altitude: 169-202 m.

Bokor: Belterület (inside the village): between 47°55'27.95"N, 19°32'47.30"E and 47°55'23.63"N, 19°32'53.72"E, altitude: 254 m.

Cserhátszentiván: Zsunyi-patak (Zsunyi brook): between 47°56'29.70"N, 19°35'21.54"E and 47°56'42.07"N, 19°35'13.29"E, altitude: 218-224 m.

Csővár: Sinkár-tó (Sinkár lake): between 47°48'7.45"N, 19°21'26.83"E and 47°47'57.97"N, 19°21'35.35"E, altitude: 162-165 m (Fig. 6).

Ecseg: Kozárdi-tó (Kozárdi lake): between 47°54'15.28"N, 19°36'36.72"E and 47°54'21.82"N, 19°36'51.85"E, altitude: 172-185 m.

Felsőtold: temető (meadow opposite of the cementery): between 47°57'53.11"N, 19°36'19.44"E and 47°57'54.36"N, 19°36'15.58"E, altitude: 234 m.

Galgaguta: Galga-patak (Galga brook): between 47°49'50.94"N, 19°23'36.37"E and 47°49'44.25"N, 19°23'41.15"E, altitude: 171-172 m.

Garáb: Garábi-patak (Garábi brook): between: 47°58'25.16"N, 19°37'29.95"E and 47°58'14.36"N, 19°37'24.59"E, altitude: 276-277 m.

Kébodony: Rákóczi-emlékmű (meadow at Rákóczi monument): between 47°55'37.03"N, 19°16'13.96"E and 47°55'34.33"N, 19°16'13.30"E, altitude: 160-162 m.

Kisecset: Kiliántelep: between 47°55'59.80"N, 19°19'32.30"E and 47°56'2.11"N, 19°19'36.76"E, altitude: 218-233 m.

Kozárd: Bézma: between 47°55'56.12"N, 19°36'37.38"E and 47°55'51.97"N, 19°36'27.53"E, altitude: 349-355 m.

Kutasó: Középső-hegy (Középső hill, former vineyards): between 47°57'3.51"N, 19°32'55.93"E and 47°57'12.90"N, 19°32'48.09"E, altitude: 284-318 m (Fig. 2).

Legénd: Hosszú-föld: between 47°52'19.05"N, 19°19'17.99"E and 47°52'18.13"N, 19°19'12.68"E, altitude: 206 m.

Nagylóc: Alsó-Zsúny: between 47°59'27.86"N, 19°36'45.75"E and 47°59'33.82"N, 19°36'37.35"E, altitude: 257-259 m (Fig. 3).

Nagylóc: Zsunypuszta: between 47°59'56.32"N, 19°37'8.74"E and 47°59'53.99"N, 19°37'6.64"E, altitude: 261 m.

Penc: Kis-völgy (Kis valley): between 47°47'41.32"N, 19°15'22.00"E and 47°47'47.59"N, 19°15'22.33"E, altitude: 149-151 m.

Penc: Obszervatórium (forest at Observatory): between 47°47'34.14"N, 19°15'53.15"E and 47°47'20.40"N, 19°16'7.32"E, altitude: 189-173 m (Fig. 4).

Penc: Ujhrabina: between 47°49'6.82"N, 19°15'49.80"E and 47°49'6.52"N, 19°15'56.41"E, altitude: 218-217 m.

Penc: Zsobrák: between 47°48'47.10"N, 19°14'28.16"E and 47°48'37.27"N, 19°14'31.81"E, altitude: 155-164 m.

Rád: Lágyas-erdő (Lágyas forest): between 47°47'14.85"N, 19°13'21.50"E and 47°47'8.51"N, 19°13'33.56"E, altitude: 135-148 m.

Results and discussion

Mosaic structure of sawfly distribution in the Cserhát Mountains

Twenty-three sampling sites were investigated in the initial time (first 4 weeks), from these 23 sampling sites, only 10 held reasonable population densities and biodiversity although all of them seemed to be ideal for sawfly collection with divers vegetation and low human disturbances. In these 10 sites (Alsópetény: Bánki-völgy, Bánk: Száva-hegy, Cserhátszentiván: Zsunyi-patak, Csővár: Sinkár-tó, Ecseg: Kozárdi-tó, Garáb: Garábi-patak, Kutasó: Középső-hegy, Nagylóc: Alsó-Zsúny, Penc: Obszervatórium, Penc: Zsobrák) we collected 557 specimens of 108 species, while in the remaining 13 sites, only 30 specimens of 16 species were collected. This kind of mosaic structure was observed everywhere in the Pannonian biogeographic region, although its acceptable scientific explanation is still missing.

Seasonal activity of flying period of sawflies

The extreme cold weather during the main flying period of sawflies in the Pannonian zoogeographical region (March-May 2021) provided unique possibility, to investigate the behaviours of populations in extreme weather conditions.

Significant shift of population peak measured at the first wave (spring population peak). It lasted 3 decades. Normally, the culmination of flying periods is positioned to the 3rd decade of April in the Pannonian Zoogeographic Region. Instead of this, now, it culminated in the third decade of May (one month later than regular time). This shift is partly or entirely caused by the extreme cold spring, not the Northern location of the mountains (compare with the data of HARIS (2011)).

Two peaks (Fig. 7) were detected during the year which can be modelled by normal distribution. The first curve is the spring flying period while the second one is that of the summer flying period. These 2 curves are separated by 40 days (June, early July), when the densities of imago populations close to zero (only 1-2 specimens were captured even with intensive collecting).

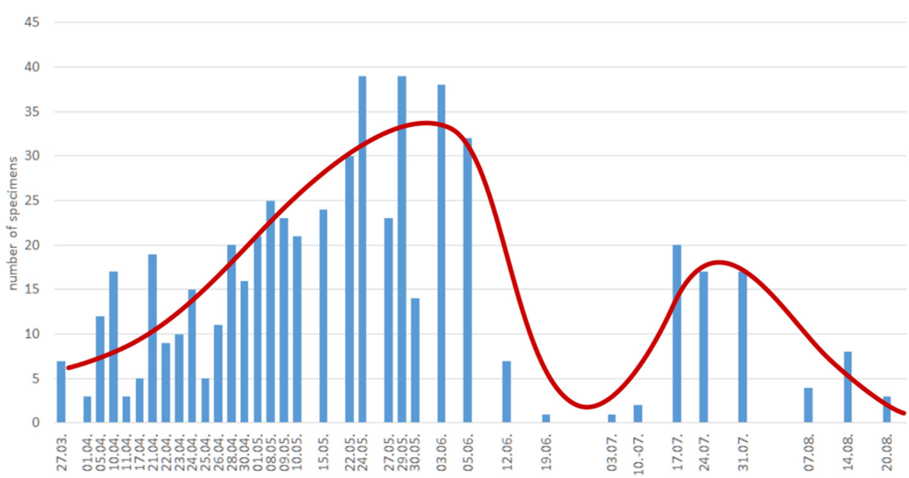

Fig. 7: Seasonal flight activity of sawflies (specimens captured per day)

Table 1: Normality probes of the 2 flight activity curves (spring and summer eruption in the Cserhát Mountains)

Parameters	Spring eruption of sawflies	Summer eruption of sawflies
Mean value	17.46	9.00
Median value	16.50	6.00
Standard Deviation	11.140457	7.782765
Skewness	0.47993	0.467894
Kurtosis	-0.57411	-1.979512
	Kolmogorov-Smirnov test	
p-value	0.97915	0.59498
Value of the K-S test statistic (D)	0.26084	0.25390
	Shapiro-Wilk test	
p-value	0.1357	0.09047
W-value	0.9435	0.8433
α-value	0.093	0.097
effect size	0.08096	0.23970

The main Gauss curve (spring flying period) has mean value 17.46 and the median is 16.50 (in number of specimens captured per day). The standard deviation of the model is 11.140457, kurtosis: -0.57411. The 0.479934 skewness value is caused by the extremely cold April. The normal distribution is verified by the 0.97915 p value (compared with the 0.26084 D value of the K-S statistics).

Opposite of this, the second active period in summer was observed between the second decade of July and the second decade of August is significantly smaller with mean value 9,000 and median value 6,000 with standard deviation: 7.782765, the model has skewness: 0.467894 and kurtosis -1.979512. Similarly to the previous, this period can be modelled with normal distribution either (D value of the K-S test 0.2539 versus the calculated p: 0.59498). According to the Shapiro-Wilk tests, the observed effect size KS - D is very small, 0.08096. This indicates that the magnitude of the difference between the sample distribution and the normal distribution is very small (Table 1). Opposite of this, in the second, summer period, the observed effect size KS - D is large, 0.2397. This indicates that the magnitude of the difference between the sample distribution and the normal distribution is large. However, since the null assumption cannot be rejected, in this case, we may ignore the effect size (Table 1).

We may say: both tests (Table 1) confirm the 2 curves normal distribution model of the seasonal flight activity of sawflies as it figured in Fig. 7.

Seasonal dynamics of sawflies biodiversity

From the 110 species, 108 were collected in the first wave of flying period and only 9 species were collected in the second wave (Fig. 8). Species richness culminated from the last decade of April till the first decade of June which is also the result of the cold spring (generally the culmination period of species diversity is nearly always in the first decade of May, sometimes in the 3rd decade of April).

Although the diversity of the first eruption of sawfly populations is 12x larger than the small diversity of the second curve, the frequency of the individuals (density of the populations) measured as high as 52% of the mean value (17.46 vs. 9.00) and 36% of the median value (16.5 vs. 6.00).

The dynamics of species composition follows the normal distribution either. It has (similarly to the previous chart) 2 curves, however, the second curve hardly elevated.

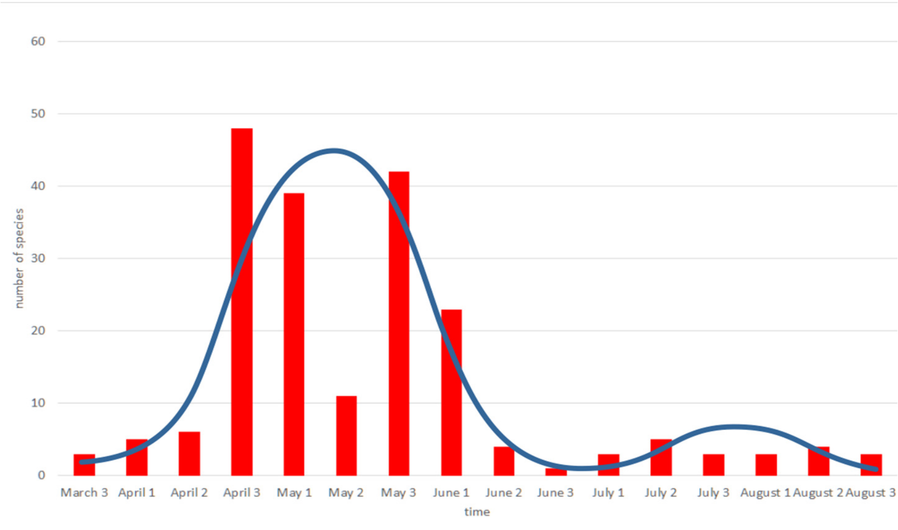

Fig. 8: Seasonal dynamics of biodiversity of sawflies in the Cserhát mountains in 2021 (number of species captured / decade)

The parameters of the spring eruption curve: mean value: 18.2. median value: 8.5. Standard deviation: 18.298755, skewness: 0.750333 and kurtosis: -1.353329 (D (K-S) 0.26084 vs. p-value 0.43115) (Table 2).

Kolmogorov–Smirnov test (Table 2) confirms normal distribution model of the 2 biodiversity curves as it figured in Fig. 8. Opposite of this, Shapiro-Wilk test doesn't confirm the normal distribution of the dynamic of sawfly biodiversity since p-value<α, therefore we shall reject the H0. It is assumed that the data is not from normal distribution. According to our opinion, in this case, Shapiro-Wilk test is not able to eliminate the

Table 2: Normality probes of 2 seasonal curves of biodiversity (spring and summer curves in the Cserhát Mountains)

Parameters	**Spring eruption**	**Summer curve**
Mean value	18.2	3.14
Median value	8.5	3.00
Standard Deviation:	18.298755	1.214986
Skewness	0.750333	-0.366392
Kurtosis	-1.353329	1.778772
	Kolmogorov-Smirnov test	
p-value	0.43115	0.43977
Value of the K-S test statistic (D)	0.26084	0.30661
	Shapiro-Wilk test	
p-value	0.02905	0.2645
W-value	0.8198	0.8828
α-value	0.060	0.102
effect size	0.2530	0.3103

influencing factor of the extreme cold spring, therefore for modelling the flight activity, the Kolmogorov–Smirnov test is more suitable.

According to the Shapiro-Wilk tests, the observed effect sizes KS - D are large, 0.253 and 0.3103. This indicates that the magnitude of the difference between the sample distribution and the normal distribution is large. But in the summer period, since the null assumption cannot be rejected, you may ignore the effect size.

Biodiversity and dominance indices

Biodiversity and dominance indices are good tools to follow the spatial and temporal change of biodiversity and species composition. They are very important to compare different areas and different periods and to recognise the tendencies. They are also useful in nature conservation and zoogeography. Unfortunately, in Hungarian sawfly faunistics, these indices haven't been used so far, however, to publish the calculated indices is still important to have data for comparison with further research preformed in different time or in different regions.

The dominant species was *Athalia rosae* (Linné, 1758) with 114 exemplars. Other frequent species (with 20 or more collected exemplars) were *Dolerus nigratus* (O.F. Müller, 1776) with 47, *Dolerus puncticollis* Thomson, 1871 with 20, *Pteronidea oligospila* (Förster, 1854) with 35, *Cephus pygmeus* (Linné, 1767) with 24 and *Calameuta punctata* (Klug, 1803) with 22 specimens. These 6 species (with 262 exemplars) amounts 45.7 % of the total collected material.

Rare and interesting species: *Sterictiphora furcata* (Villers, 1789): "all checked specimens proved to be *S. angelicae*" (ROLLER & HARIS 2008). We were not able to cancel this species from the fauna of the Carpatian Basin in that time, since many old specimen mainly from the 19th century were not available. However, this is the first documented specimen from the Carpathian Basin following the sub-recent revision of KOCH 1988.

Other rare species: *Empria hungarica* (Konow, 1895), *Aprosthema austriacum* (Konow, 1892), *Arge pleuritica* (Klug, 1834), *Monardis plana* (Klug, 1817), *Hoplocampa pectoralis* C. G. Thomson, 1871, *Pachynematus moerens* (Förster, 1854) and *Pristiphora abbreviata* (Hartig, 1837).

Table 3: Biodiversity and dominance indices of sawflies, Cserhát Mountains, 2021

Index	Value	Index	Value
Simpson Index	0.06	Berger-Parker Dominance Index	0.2
Dominance Index	0.94	Inverted Berger-Parker Dominance	5.03
Reciprocal Simpson Index	17.11	Menhinick Index	4.6
Shannon-Wiener Index log2	5.37	Buzas and Gibson's Index	0.38
Shannon-Wiener Index ln	3.72	Equitability Index	0.79
Shannon-Wiener Index log10	1.62	Margalef Richness Index	17.16
Gini Coeffificient	0.65		

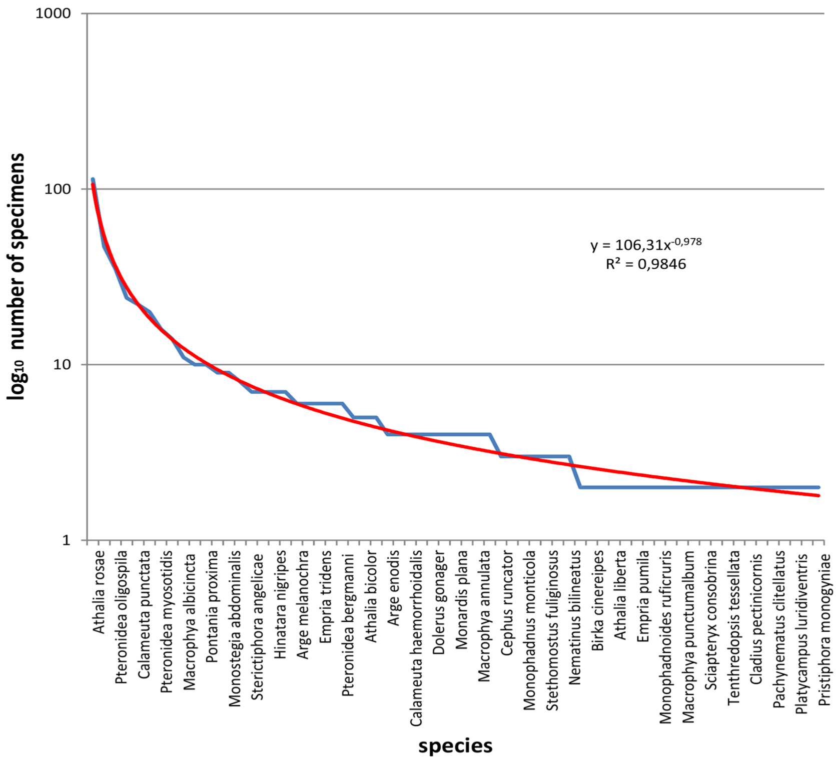

Fig. 9: Dominance diversity curve of assemblage of sawflies in the Cserhát Montains

Excellent fit (98.45%) were detected to the $100x^{-1}$ curve (with $y=106.31x^{-0.978}$ experienced parameters) (Fig. 9).

Only Argidae, Cephidae and Tenthredinidae families were collected. The other families of Symphyta remained hidden. It indicates, these families are not frequent in the Cserhát Mountains including the insect pests from these families. Also interesting the total lack of summer flying Tenthredo L. species.

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