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Population Dynamics of the Plantain-Banana Weevil, *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae) in Bayelsa State, Southern Nigeria

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ABSTRACT: Population dynamics studies reveal the fluctuations in an organism's population over time, in relation to prevailing climatic conditions; thus providing a fundamental background for evaluating and determining appropriate control strategies for adoption. This study in Bayelsa State, Southern Nigeria has revealed that *C. sordidus* population experiences a gradual build-up with onset of rains (early March), and attain peaks between May and early November. The population however, declines with the commencement of the dry season in November, and continues till February (just before the wet season). Rainfall frequency was found to be the main factor influencing the pest's population (i.e. not merely monthly precipitation or Total rainfall); the correlations were positive and significant at both Okarki and Akenfa (r=0.540, P<0.05; r= 0.515, P<0.05) respectively. Average Relative humidity similarly had a significant correlation with the pest's population at Okarki and Akenfa (r=0.516, P<0.05; r=0.565, P<0.05). Consequently the dry season (November – February) often associated with both low rainfall and rainfall frequencies, and with low relative humidity, witnessed significant falls in the pest's population. Temperature did not show any significant influence on the pest's population performance at all the locations in this study, obviously because survey/sampling times were restricted to daytimes only. This pest is known to have a nocturnal rhythm. It is recommended that controls against this pest be targeted between November and February, as it appears the most appropriate period to prevent the pest's population from rising and reaching alarming and destructive levels.

Keywords: Population dynamics, Population peaks, Climatic parameters, Rainfall frequency, Correlation matrix

Introduction

The plantain-banana weevil, *Cosmopolites sordidus* (Coleoptera: Curculionidae) is considered as the major insect pest of Musa (i.e. Plantain and banana crops) worldwide (Rhino *et al*., 2010, Tinzaara *et al*., 2011, Masanza, 2018). Damages to these crops range from tunneling on growing points of the corms and setting-up of secondary rots (Jones, 1986), to total crop failures (Gold *et al*., 2001). No cultivars are known to have total resistance to the pest; though some are more susceptible than others (Viswanath, 1981, Mesquita *et al*., 1984, Gold *et al*., 2001). Current approaches at control have involved integration of cultural (pseudostem trapping, crop hygiene, careful varietal selection), semiochemicals (pheromonal traps) and chemical uses (poison baiting and properly selected insecticides).

All known control attempts have yet to give lasting and effective control, against this pest due mainly to its life cycle and cryptic nature. Its eggs are laid singly at bases and corms of the plants and emerging larvae immediately burrow into the crop's pseudostems, where the pest (borer) spends a greater percentage of its life cycle – shielded from external chemical sprays and other inhibitors. Emerging adults are free-living, and are

protected with a tough exoskeleton. They are also mainly nocturnal and hence hardly visible or accessible for easy and swift control.
Knowledge of the biology, ecology and behavior of pests are essential for their effective management (Bottrell, 1979, Hill and Waller, 1982, Kumar, 1984, Srivastava and Dhaliwal, 2012). The understanding of the population dynamics of *C. sordidus*, would be fundamental for its comprehensive and sustainable control (Quieroz *et al*., 2017, Masanza, 2018).
This study was embarked upon in Bayelsa State (Southern Nigeria) – a major plantain and banana producing region of the country, with a view to establishing the population peaks and lows for this pest in a year, so as to exploit such info against it. Appropriate control efforts that target critical times (or vulnerable periods) of a pest's life would ensure most effective control; it would even avert such undesirable consequences as pollutions, resistance development, residue issues etc. often associated with some control options. Most importantly, it would guarantee cost effectiveness since *Musa* plants (for trapping materials) are readily available and only attract relatively cheaper costs, compared to the other known options. A pheromonal (semiochemical) control against this pest for instance, would involve USD 185 approx N90,000 per year per hectare (Alpizar *et al.*, 2012) compared to virtually little or nothing with plantain pseudostems traps – a method that has been in use against the pest for over 50 years now (Gold et al 2001, Alpizar et al, 2012). It must however, be stated here that for large farm hectarages pseudostem trapping alone may prove too laborious and inappropriate.

Materials and Methods

This study was conducted at three (3) different locations in the Niger Delta belt of Bayelsa State (lying within Latitude 4°15'N and 5°23'S and Longitude 5°22'N and 6°45'E) in Southern Nigeria, namely:

- Bolou-Orua (5°6'55.056'N and 6°72.004'E)
- Okarki (4.9839°N and 6.4286°E)
- Akenfa (5.0064°N and 6.3866°E) (Fig. 1).

At each location, plantain farms of approximately 1 acre or above, and hosting at least 250 plantain stands were used. Already harvested stands and/or fallen ones were always targeted and solicited for use as trapping materials from volunteer/partnering farmers. Fortnightly, these pseudostems would be collected and splitted into traps of 15 cm long, and placed randomly across the farms at each location.

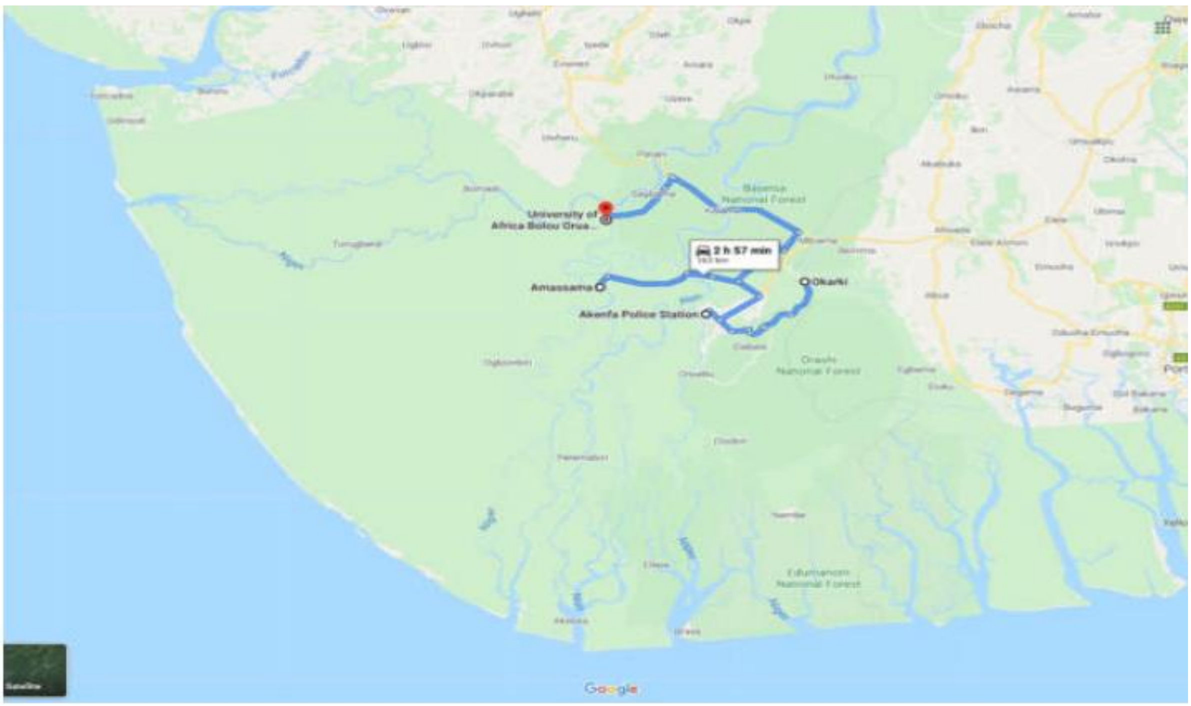

Fig. 1: Map of Bayelsa State showing study locations (Bolou-Orua, Okarki and Akenfa) and the Meterological Station at Amassoma

At weekly intervals, the traps were inspected for weevil presence. Traps were replaced fortnightly with new ones. Weekly catches were summed to obtain monthly average counts. These monthly average counts (i.e. monthly weevil populations) were at the end of the survey, compared with the prevailing climatic conditions of rainfall, temperature and relative humidity for possible correlations. Climatic data used in this study were obtained from the nearest Meteorological Station, located at Geography Department, Niger Delta University, Amassoma (4.9731° N, 6.1090° E) – the primary source of climatic data. The monthly pest populations for the different locations were further tested against the available online climatic data for the region **(**courtesy: ezoic climate-data.org) to verify/authenticate all correlation results. This secondary climatic data source, is herein referred to as the “Standard” and is so presented in the Tables 1-3 under Results Section as: Standard Total Rainfall and Standard Temperature (NB: only two parameters, Total rainfall and temperature data were supplied by this data-source).

Results

The fluctuations in monthly average counts (or monthly pest populations for the three locations as well as the prevailing climatic parameters (monthly total rainfall, average temperature and average relative humidity) over the 12 months study period (August 2018 – July 2019) are presented in Table 1 and Fig. 2. The trend for all three locations was a fall in pest population with onset of the dry season (i.e. from November to late February); and a gradual rise in the populations, with the wet season (i.e. from early March up till late October). Fig. 3 specifically highlights the corresponding Rainfall frequencies for the different months during this period of investigation (i.e. August 2018-July 2019). Rainfalls were generally more frequent in the wet season (April through October – a range of 5-15 rainfalls per month, [Table 1]) thus supporting high pest populations; and relatively less frequent during the dry season (November through March – range of 2-4 rainfalls per month) hence the observed low pest populations at such times.

Table 1. Monthly data on the plantain-banana weevil Populations and prevailing Climatic parameters in Bayelsa State, Southern Nigeria (Aug 2018 – July 2019)

Time of Year	Bolou	Okarki	Akenfa	Total Rainfall	Rainfall Frequency*	Average Temp	Average Relative Humidity	Standard Total Rainfall	Standard Temp
2018 Aug	13	12.5	13.5	179	0.29	27.6	76.5	280	25.2
Sept	13.3	16.8	17.2	344	0.5	28	76.6	491	25.2
Oct	18.5	15	15	260	0.39	26.2	72.2	417	25.5
Nov	18.8	13	18	39	0.13	27.5	73.1	192	25.9
Dec	13.3	4	6.4	82	0.13	27.8	69.8	79	26.7
2019 Jan	6.3	3.8	5.3	127	0.13	26.4	68.6	40	26.8
Feb	8.3	4.3	6.3	50	0.11	26.9	71.5	78	26.9
Mar	9.5	12	13.8	84	0.1	27.5	70.9	142	27.6
Apr	13.3	18	16.5	106	0.17	27.5	70	207	28
May	10	20	18.5	102	0.19	27.6	72.7	299	27.8
Jun	12	16.6	21.6	249	0.37	27.4	73.6	416	27.1
July	5.3	16.3	16.8	442	0.52	28	74	427	26.5

* No. of rainfalls per month (9, 14, 12, 4, 4, 4, 2, 3, 5, 6, 11, 15) respectively

The Correlation matrix for all possible variables (i.e. monthly pest populations at the locations and the prevailing climatic parameters) for the period under investigation is presented in Table 2; while Table 3 presents the summary. Rainfall frequency and average relative humidity showed significant influences on the pest populations in 2 out of the 3 stations studied. Effect of Monthly Total rainfall was not readily visible in this study, but when checked against the Standard Total rainfall it proved highly significant

Table 2: The Correlation Matrix for all the variables (i.e. locations versus climatic parameters and all interactions)

		Bolou	Okarki	Akenfa	Tot Rfall	Rfall Freq	Av Temp	Av RH	Std Tot Rfall	Std Temp
Bolou	P. Correlation	1	.236	.331	-.178	.013	-.100	.207	.220	-.436
	Sig (2-Tailed)		.459	.294	.579	.968	.756	.518	.492	.157
	N	12	12	12	12	12	12	12	12	12
Okarki	P Correlation	.236	1	.930**	.447	.540*	.370	.516*	.781**	.061
	Sig (2-Tailed)	.459		.000	.145	.070	.237	.086	.003	.852
	N	12	12	12	12	12	12	12	12	12
Akenfa	P. Correlation	.331	.930**	1	.404	.515*	.395	.565*	.769**	-.005
	Sig (2-Tailed)	.294	.000		.192	.086	.204	.055	.003	.988
	N	12	12	12	12	12	12	12	12	12
Tot Rfall	P. Correlation	-.178	.447	.404	1	.969**	.234	.559*	.827**	-.415
	Sig (2-Tailed)	.579	.145	.192		.055	.463	.059	.001	.180
	N	12	12	12	12	12	12	12	12	12
Rfall Freq	P. Correlation	.013	.540*	.515*	.969**	1	.251	.693**	.921**	-.513
	Sig (2-Tailed	.968	.070	.086	.000		.431	.013	.000	.088
	N	12	12	12	12	12	12	12	12	12
Av Temp	P. Correlation	-.100	.370	.395	.234	.251	1	.472	.278	.039
	Sig (2-Tailed)	.756	.237	.204	.463	.431		.121	.382	.905
	N	12	12	12	12	12	12	12	12	12
Av RH	P. Correlation	.207	.516*	.565*	.559*	.693*	.472	1	.748**	-.643
	Sig (2-Tailed)	.518	.086	.056	.059	.013	.121		.005	.024
	N	12	12	12	12	12	12	12	12	12
Std Tot Rfall	P. Correlation	.220	.781**	.769**	.827**	.921**	.278	.748**	1	-.406
	Sig (2-Tailed)	.492	.003	.003	.001	.000	.382	.005		.191
	N	12	12	12	12	12	12	12	12	12
Std Temp	Correlation	-.436	.061	-.005	-.415	-.513	.039	-.643	-.406	1
	Sig (2-Tailed)	.157	.852	.988	.180	.088	.905	.024	.191	
	N	12	12	12	12	12	12	12	12	12

Pearson Correlation * Significant at 0.05 level (2 tailed) ** Significant at 0.01 level (2 tailed)

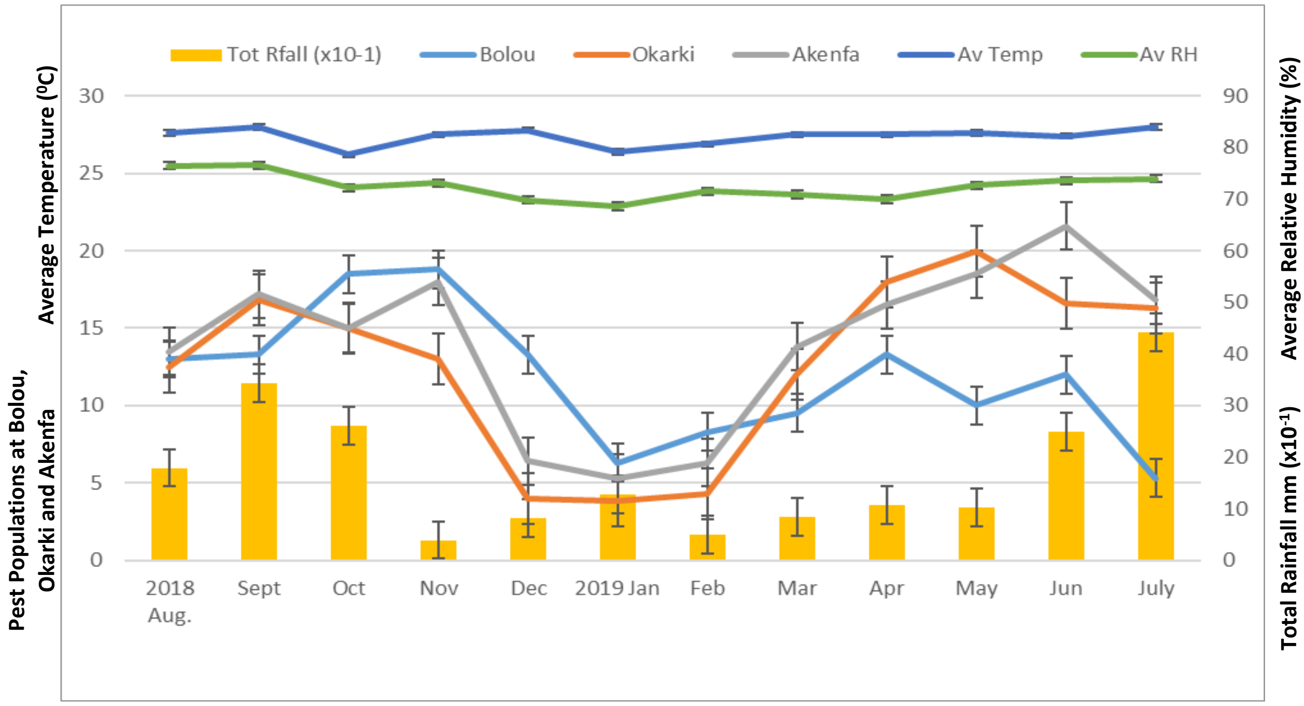

Fig. 2: The influence of Climatic Parameters on the plantain banana weevil Population Dynamics in Bayelsa State, S. Nigeria (Aug. 2018 – July 2019)

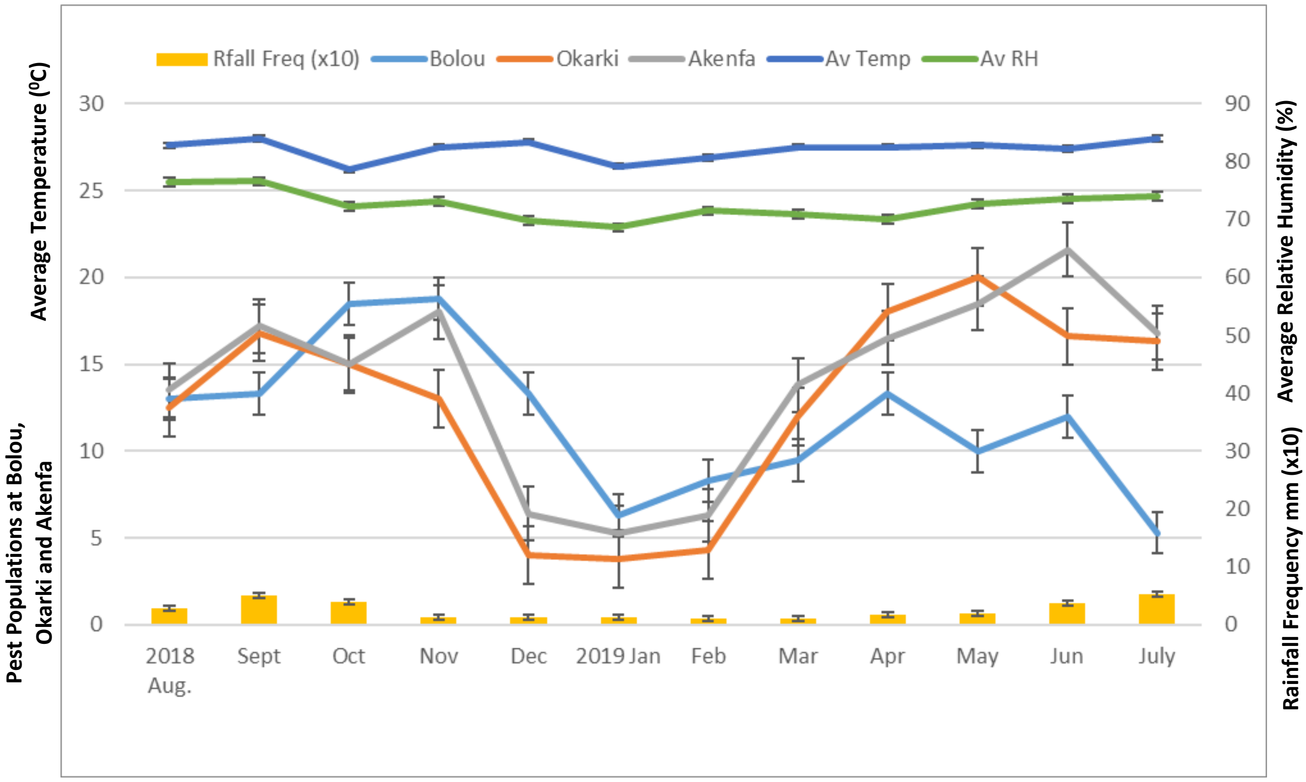

Fig. 3: Impact of Rainfall Frequency on the plantain-banana weevil Population Dynamics in Bayelsa State, Southern Nigeria (Aug. 2018 – July 2019

Table 3: The Correlations between Pest populations at Locations and the prevailing Climatic Conditions in Bayelsa State, Southern Nigeria

		Total Rainfall (mm)	Rainfall Frequency	Average Temp (ºC)	Av. Relative Humidity (%)	Std Total Rainfall (mm)	Standard Temp (ºC)
	P. Correlation	-.178	.013	-.100	.207	.220	-.436
	Sig (2Tailed)	.579	.968	.756	.518	..492	.157
Bolou	N	12	12	12	12	12	12
	P. Correlation	.447	.540*	.370	.516*	.781**	.061
	Sig (2Tailed)	.145	.070	.237	.086	.003	.852
Okarki	N	12	12	12	12	12	12
	P. Correlation	.404	.515*	.395	.565*	.769**	-.005
	Sig (2Tailed)	.192	.086	.204	.056	.003	.988
Akenfa	N	12	12	12	12	12	12

Pearson Correlation   * Significant at 0.05 level (2 tailed)   ** Significant at 0.01 level (2 tailed)

Discussion

The results have clearly shown that Rainfall frequency (i.e. not merely monthly precipitation or Total rainfall) has a significant effect on the population dynamics of *C. sordidus.* Not surprisingly months with some fairly good Total rainfall (November-February, Fig. 2) but with correspondingly low Rainfall frequencies (Fig. 3) witnessed falls in weevil populations; emphasizing the fact that the more frequent the rains (as seen from April-October, Fig. 3) the higher the weevil populations. Rainfall frequencies thus had a positive and significant correlation with pest populations as seen at Okarki (r=.560, P<0.05), and Akenfa (r=.515, P<0.05) but not at Bolou Orua. The effect of monthly Total Rainfall on the pest population however, was not readily obvious for these communities, but when checked against the "Standard" (i.e. the Standard Total Rainfall) marked significant results were observed (r=.781, P<0.01, and r-.769, P<0.01) for Okarki and Akenfa respectively. Although it still remained non-significant at Bolou Orua. The possible explanation for why Total Rainfall was not significant here may be because the Standard data are those that had been obtained over an extended timeframe (several years or perhaps decades), but that of this study was only for 12 months. A prolonged or extended study duration would increase the sample size from 12 and thus lead to improved correlation values.

The logical reason for poor and low correlations between pest population and climatic parameters at Bolou Orua location may be due to its long distance away from the Met Station Amassoma. If the Met Station had been at this base, the effect of weather on the population fluctuations may perhaps have been more glaring.

Rainfall influence on *C. sordidus* populations have also been reported by other workers in the past. Gold *et al*. (1999) found higher catches during the wet season in Uganda than during the dry season. Pantoja *et al*. (2006) in Puerto Rico and Reddy *et al*. (2008) all indicated higher capture rates in the rainy season. Alpizar *et al*. (1998) also reported higher catches in Costa Rica for both *C. sordidus* and *Metamasius hemipterus* during periods of high rainfall. According to Treverrow (1985) in New South Wales, all four (4) stages of the pest are associated with the plant and are present throughout the year, but the emergence of adults reaches peaks from September – November & in the late summer.

Average Relative humidity similarly had significant correlations with the pest's population especially at Okarki (r=.565, P<0.05) and at Akenfa (r=.565, P<0.05); but not at Bolou Orua. The results agree with findings by (Uzakah, 1995 and 2018) that *C. sordidus* activity is positively correlated with relative humidity. Quieroz *et al*. (2017) in Brazil, also found that high Relative Humidity led to increased capturing of the pest; an observation that was also corroborated by Gold *et al*. (2001), as they reported a hygroscopic nature for the pest..

Temperature (i.e. average temperature and even the Standard Temperature values) did not show any significant effect on the dynamics of this pest's population. The reason for this is very obvious – all samplings/surveys were done during the day. Uzakah's work (1995 and 2018) revealed a negative correlation between *C. sordidus* activity and temperature; and he reported an endogenously controlled nocturnal rhythm for the pest. Gold *et al.* (2001) also reported that the pest remained sedentary at daytime; and during the dry season (Gold *et al.*, 1999).

The findings made in this study have clearly revealed that *C. sordidus* population builds up with the rains (late February/early March, reaching peaks between May – October (or early November), and thereafter falling with the start of the dry season (November – February) at all the three locations. It would therefore be recommended that the best period for control strategies or treatments against this pest should be between November - late Feb (i.e. in the dry season) or before the commencement of rains in March, in order to prevent their build-up to alarming and destructive levels.

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