POPULATION DYNAMICS OF *MEGALUROTHRIPS SJOSTEDTI* AND *FRANKLINIELLA OCCIDENTALIS* (THYSANOPTERA: THRIPIDAE) IN A FRENCH BEAN (*PHASEOLUS VULGARIS* L.) AGROECOSYSTEM

L. M. Gitonga[1] and B. Löhr[2]
[1]Jomo Kenyatta University of Agriculture and Technology Nairobi, Kenya
[2]International Centre for Insect Physiology and Ecology Nairobi, Kenya
E-mail: gitonga@fsc.jkuat.ac.ke

ABSTRACT
The temporal and spatial distribution patterns of *Megalurothrips sjostedti* Trybom and *Frankliniella occidentalis* Pergande on French beans was determined so as to come up with appropriate sampling methods through development of constant precision sequential sampling plans. Fieldwork was carried out at three localities. Distribution of larvae and adult thrips was assessed using Taylor's power law, whose constants were used to develop constant-precision level sampling plans. Both larvae and adult thrips were present in the crop all year round, with population peaks for both species occurring at different times of the year in all localities. *M. sjostedti* peaked during the period following the rains and in the absence of *F. occidentalis.* The latter peaked during the hot and dry months of the year for all localities. There was clear displacement of *M. sjostedti* by *F. occidentalis* in the crop during the hot and dry months of the year, and in the hot and drier parts of French bean growing. Both larvae and adults were aggregated, but significantly higher aggregation was observed for larvae than adult thrips in the flowers. These findings on alternation of occurrence, displacement, habitat partitioning and sampling have implications on thrips control in the context of IPM such as sampling for thrips and commencement of intervention in the vegetative stage in addition to determining the correct control strategy when either of the species is abundant in the crop.

Key words: Thysanoptera, thrips, abundance, sampling plans

1.0 INTRODUCTION

Among the vegetable crops, French beans or snap beans (*Phaseolus vulgaris* L.) has dominated horticultural fresh produce exported from Kenya mostly to European destinations. French bean farming is largely a small-scale operation in which about 50,000 families are involved in production. A further 500,000 derive livelihood directly from the export of French beans (Michalik *et al*., 2001).

French beans are grown in a wide variety of agroecological zones in Kenya. The main growing areas include: Meru, Embu, Kirinyaga, Nyeri, Muranga, Maragua and Kiambu. Other areas include Machakos, Makueni, Naivasha, Bungoma, Vihiga, Trans Nzoia and Kericho (Gitonga, 1999). Popular cultivars of French beans grown in Kenya include: Samantha, Loby, Gloria, Paulista, Nerisa, Amy, Morgan and Vernadon (Ministry of Agriculture (MoA) and Lapan (Ministry of Agriculture and JICA, 2002).

Although French bean is an important export crop, export figures indicate that there has been a noticeable decline due to, among other factors, difficulties in the protection of the crop against insect pests and diseases. The most important insect pests are bean flies, bean flower thrips, aphids, pod borers and red spider mites, in addition to various root diseases (Seif *et al.,* 2001).

The ability to predict occurrence and abundance of an insect pest in an area, or an individual field, will rely on the understanding of spatial and temporal factors that influence its movement through the crop sequence (North and Shelton, 1986). Sampling programme are dependent on knowledge of spatial distribution of the population being sampled, which may not be constant among species (Kuno, 1991). The study of the population dynamics, on the other hand, requires appropriate sampling methods as a pre-requisite (Tamo *et al.*, 1993). Both *M. sjostedti* and *F. occidentalis* have been found to show diurnal population trends (Kasina *et al*., 2006). The objectives of this study were to determine the temporal and spatial distribution patterns of *F. occidentalis* and *M. sjostedti* occurring on French beans in Kenya, and develop constant-precision level sequential sampling plans.

2.0 MATERIALS AND METHODS

Studies were carried out in high and low intensive French bean production systems. Thrips population development was studied under varying temperature and humidity conditions as per the different localities. Field experiments were carried out at three localities namely, Kaguru Farmers Training Centre (FTC) ($37^0 30'$ E 0^0), at 1,527 m above sea level (asl) and receiving an annual rainfall of 1,765 mm), and at Machakos FTC (37^0 $30'$E 1^0 $30'$S), at 1,600 m asl and receiving an annual rainfall of 800 mm and Jomo Kenyatta University of Agriculture and Technology (JKUAT) ($01^\circ 01'$S $37^\circ 06'$S), altitude and 1600 m asl, receiving an annual rainfall of 950 mm (Jaetzold and Schmidt, 1983). Kaguru FTC is about 230 km in Meru District, while Machakos FTC is about 75 km from Nairobi, in Machakos District. Both are in Eastern Province. JKUAT is about 35 km from Nairobi, in Thika District, Central Province.

The French bean, *Phaseolus vulgaris* L variety Monel was grown in 10 x 10 m plots replicated 4 times at each of the localities and planting dates. The plots were separated by 1 m - paths. The beans were sown monthly, throughout the year (1998/1999), at a spacing of 60 cm between the rows and 10 cm within the rows. Prior to sowing, bean seeds were treated against attacks by bean flies using Imidacroprid (Gaucho®) and Fipronil (Vitavax®) at the rates of 8 g/kg and 4.8 ml/kg seed mixtures respectively. At sowing, diammonium phosphate (DAP) fertilizer was applied at the rate of 60 kg/ha, while calcium ammonium nitrate (CAN) was applied as a top dressing at the rate of 60 kg/ha when the plants were three weeks old (first trifoliate leaf stage). The fields were kept free of weeds and irrigated as necessary.

Ten leaves, fifteen flower buds and fifteen flowers per plot, were collected from as many randomly selected plants. Sampling of the bean leaves commenced 21 days after sowing. The leaves were placed in 300 ml plastic cups containing 60% alcohol and tightly covered with a lid. Flower buds and flowers were collected in 30 ml specimen vials containing 60% alcohol. The samples were taken to the laboratory where the thrips were removed from the leaves by washing them twice in 200 ml of 60% alcohol in 300 ml plastic cups tightly closed with a lid. The flower buds and flowers were first dissected, washed twice in 60% alcohol and then filtered through Whatman No. 1, 55 mm filter paper. Adult thrips were counted and identified using keys described by Palmer *et al.* (1989) while the immature ones were counted but not identified to species.

2.1 Aggregation Characteristics

The distribution of larvae and adult *F. occidentalis* and *M. sjostedti* in relation to the selected sampling unit at each locality and for each planting was examined using Taylor's power law (Taylor, 1961). The sample units were leaf, flower bud and flower, randomly collected. Means and variances were fitted to Taylor's power law, which expresses the functional relationship between the variance (s^2) and mean (μ) as:

$s^2 = a\,\mu^b$ or $s^2 = b \log_{10} m + \log_{10} a$ ....(1)

where m is the number of adult thrips or larvae per plant part at each locality on each sampling date, s^2 the variance associated with m, *b* the slope of the regression line and *a* the anti-log of the intercept. The goodness-of-fit of each of the regression models was evaluated by estimates of r^2. A t-test was used to determine the significance of the departure of each of the slopes from unity.

Coefficients from Taylor power law regression were used to develop constant precision-level sampling plans for the total number of thrips. The sampling stop lines were calculated from the following formula (Green 1970):

$\text{Log } Tn = (\log (Do^2/a)) / (b-2) + ((b-1) / (b-2)) \log n$ ....(2)

where a and b are coefficients from Taylor regression, Tn = cumulative number of thrips, n = sample size and Do = fixed levels of precision used in estimating stop lines were 0.20, 0.25 and 0.30. The number of samples necessary to estimate the mean with fixed precision was determined by solving for n in the equation below:

$n = ax^{(b-2)}/Do^2$ ....(3)

where a and b are coefficients from Taylor's power law regression.

3.0 RESULTS

3.1 Temporal Distribution of Thrips on French Beans

The weather parameters and the population trends of the adults and larvae of *M. sjostedti* and *F. occidentalis* for the three sites are shown in Figures 1, 2 and 3. Each of the three sites had two distinct rainy seasons. Thrips larvae and adults of both species were present in the crop throughout the year in all the localities, albeit in small numbers at times.

Whereas *M. sjostedti* and *F. occidentalis* adults occurred in the crop throughout the year, their populations peaked at different times of the year, at all the localities (Figures 1, 2 and 3). There were three population peaks of *M. sjostedti* and two of *F. occidentalis* adults, in alternation, at Kaguru (Figure 1). It is also noteworthy that there were three larval peaks at Kaguru (Figure 1). There was only one population peak, in alternation, for each of *M. sjostedti* and *F. occidentalis* adults at JKUAT (Figure 2). It appears that there were two larval peaks at JKUAT, in between which there was some rain (Figure 2). At Machakos, each of the adult thrips and larvae had only one peak (Figure 3). The population peaks of the larvae coincided more closely with those of adult *M. sjostedti* as opposed to those of *F. occidentalis* (Figures 1, 2 and 3).

3.2 Spatial Distribution

The relationship between log variance and log mean for both adult *F. occidentalis* and *M. sjostedti* and larvae was linear for all the plant parts sampled in the three localities. There were no significant differences between the slopes (b values) of the two adult thrips and larvae in any of the plant parts, and also between the localities (Table 1). Consequently, data of particular plant parts from the three localities (where applicable) was pooled and aggregation coefficients determined (Table 2). Both a and b values from the pooled data were used to develop the appropriate sampling plans. Taylor's power law adequately described the relationship between variance and mean for both adult thrips and larvae for all the plant parts and localities as shown by the high coefficients of determination (r^2) and significant regressions (Table 2). Earlier work in these studies had shown that *M. sjostedti* did not thrive on French bean leaves, and therefore, no Taylor power law analysis on the leaves were carried out with regard to *M. sjostedti*. *F. occidentalis* and *M. sjostedti* adults and larvae were aggregated in the flower buds, flowers and leaves of French beans at all the localities. The aggregation coefficients of the thrips larvae, in any plant part, were higher than the aggregation coefficients of the adult thrips in the same plant parts. *F. occidentalis* had the next highest aggregation coefficients while *M. sjostedti* had the lowest.

Sequential sampling plans for *F. occidentalis* and *M. sjostedti* are presented in Figure 4. They were calculated using Green's equation (Green ,1970) and Taylor's power law of regression. The sample sizes required to estimate the densities of the thrips increased as the precision increased. Using the formula: $n = ax^{(b-2)}/Do^2$, the optimum sample sizes required for both *F. occidentalis* and *M. sjostedti* would be 14 and 19 flowers respectively at Do = 0.20, while at 0.25 the optimum sample sizes would be nine and six for *F. occidentalis* and *M. sjostedti* respectively.

4.0 DISCUSSION AND CONCLUSIONS

The population peaks of larvae at all the sites coincided closely with those of the adult species, allowing for maturation time. It, therefore, follows that the larval peaks can be attributed to whichever of the adult species that was abundant in the crop at that particular time. The close coincidence of larval and adult *M. sjostedti* peaks can be explained in part by the ability of *F. occidentalis* to use the leaves as oviposition substrate, unlike *M. sjostedti* (Gitonga, 1999). Consequently, all larvae of *F occidentalis* may not have been captured since the data reflected here are for flowers. *Megalurothrips sjostedti* was distinctly more prevalent during the period following the rains, and also when the populations of *F. occidentalis* were low. This could be a pointer to differences in the humidity requirements by the two thrips species, with *M. sjostedti* probably having a higher humidity requirement for development than *F. occidentalis*. Studies by Ezueh (1981) on *M. sjostedti* in cowpeas however, showed that *M. sjostedti* was more abundant in the drier than in wetter months. This is contrary to these findings and also to similar studies by Alghali (1991) on *M. sjostedti* in cowpeas, who reported that populations of *M. sjostedti* crashed when ambient temperatures rose above 30°C. An alternative explanation for the peaks of *M. sjostedti* and *F occidentalis* on the French bean crop may be that *M. sjostedti* was displaced by *F. occidentalis* from the flowers, assuming that both species were washed off the plants by the rains (Kirk, 1997). Given that no other thrips species were reported on cowpeas in the studies by Alghali (1991), it implies that *M. sjostedti* may have been present on the cowpea crop without a competitor.

Displacement of one species by the other, therefore, is a possible explanation for the alternation of population peaks of the two species. The data presented here show that *F. occidentalis* thrives during the hot and dry months of the year at all the localities. The behavior of *F. occidentalis* could be explained in many ways. On the one hand, the optimum temperature for the development of *F. occidentalis* is high

(30-31°C) (Gaum *et al.,* 1994; van Rijn *et al.,* 1995). Laboratory studies have confirmed this for *F. occidentalis* obtained from the French beans in this region (Gitonga *et al.,* 2002a).

On the other hand, *F. occidentalis* has been found to thrive well on the leaves of French beans as well as on the flowers. It is, therefore, present in the leaves during the pre-flowering phase of the crop, from which they invade the flowers once they are formed. This confers an advantage to *F. occidentalis* over *M. sjostedti.* However, this advantage is removed when rains wash all thrips away from both leaves and flowers (Kirk, 1997). Moreover, when the ambient temperatures are very high, *F. occidentalis* can retreat into the leafy strata where the temperatures may be more conducive.

The seasonal variations in the numbers of thrips on the French bean crop appears to be related to climatic conditions. There were overlapping crops at the susceptible growth stages throughout the period of the year, hence availability of food source could not have been responsible for the sharp fall in the numbers of the thrips observed. Ezueh (1981) attributed the decline in the thrips numbers following the rains to washing down of the thrips by the rains or their drowning in hiding places. Boissot *et al.* (1998) postulated that heavy rainfalls saturate the soil and submerge the pupae. Other unknown factors in need of investigation are differential reproduction rates and humidity requirements of the two species

Frankliniella occidentalis and *M. sjostedti* adult thrips and larvae were each aggregated in the respective plant parts. However, larvae were more aggregated than the adult thrips. Reduced aggregation in the adult thrips could have been due to dispersal from their oviposition sites and accumulated mortality (Overholt *et al.*, 1994). The low aggregation values reported by Salifu and Hodgson (1987), for *M. sjostedti* larvae, as compared to those of the adult thrips on cowpea flowers were probably due to the pooling of the data. The higher aggregation observed in the flowers for both the adult and larval thrips was a reflection of their preference for the flowers as feeding and oviposition sites (Salifu and Hogdson, 1987). Aggregated distributions of *F. occidentalis* have also been recorded for different plant parts of cucumbers (Steiner 1990) and tomatoes (Cho *et al.*, 1995).

The results discussed are part of a wider study on bioecological studies of thrips in French bean agroecosystems in Kenya (Gitonga *et al.*, 2002b; 2002c). It is apparent that growing of French beans in the period after rains and in the cooler and relatively wet areas of the country and seasons may be more cost effective as it would necessitate little use of chemical control. This recommendation emanates from the finding that both thrips species occur in the crop throughout the year but exhibiting clear alternation of population peaks. This recommendation takes into consideration the fact that *F. occidentalis* is more difficult to control than *M. sjostedti.*

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REFERENCES

M. A. Aliyagen (1991). The Effects of some Agrometeorogical Factors on the Fluctuation of Flower Thrips, *Megalurothrips sjostedti* Trybom (Thysanoptera: Thripidae), on two Cowpea Varieties. *J. Plant Protection in the Tropics*, **8,** pp 63-68.

N. Boissot , B. Reynaud and P. Letourmy (1998). Temporal Analysis of Western Flower Thrips (*Thysanoptera: Thripidae*) Population Dynamics on Reunion Island. *Environ. Entommol*. **27**, pp 1437-1443.

K. Cho, C. S.Ekel, J. F. Walgenbach and G. G. Kennedy (1995). Spatial Distribution and Sampling Procedures for *Frankliniella* spp. (*Thysanoptera: Thripidae*) in Staked Tomato. *J. Econ. Entomol'.,* **88**, pp1658-1665.

M. I. Ezueh (1981). Nature and Significance of Preflowering Damage by Thrips to Cowpea. *Entomologia Experimentalis et. Applicata*. **29**, pp 305-312.

W. G. Gaum, J. H. Giliomee and K. L. Pringle (1994). Life History and Life History Tables of Western Flower Thrips *Frankliniella occidentalis* (*Thysanoptera: Thripidae*) on English cucumbers. *Bull. Entomol. Res*., **84**: pp 219-224.

L. M. Gitonga (1999). Bioecology of Thrips in French bean Growing agroecosystems in Kenya. PhD Thesis pp 176.

L. M. Gitonga, B. Lohr, W. A.Overholt, J. K Magambo and J. M. Mueke (2002a). Temperature-dependent development of *Megalurothrips sjostedti* and *Frankliniella occidentalis* (Thysanoptera:Thripidae). *African Entomology,* **10**, pp 325-331.

L. M.Gitonga, W. A.Overholt, B.Lohr, J. K. Magambo and J. M. Mueke (2002b). Functional Response of *Orius albidipennis* (Hemiptera:Anthocoridae) to *Megalurothrips sjostedti* (Thysanoptera:Thripidae). *Biological Control,* **24**, pp 1-6.

L. M Gitonga, B. Lohr, W. A. Overholt, J. K. Magambo and J. M. Mueke (2002c). Effects of Temperature on the Development of *Orius albidipennis* (Hemiptera:Anthocoridae), a predator of the African Legume FlowerThrips, *Megalurothrips sjostedti* (Thysanoptera:Thripidae). *Insect science and its application,* **22**, pp 215-220.

R. H. Green (1970). On Fixed Precision Levels Sequential Sampling. *Res. Pop. Ecol*., **12**, pp 249-251.

R. Jaetzold, and H. Schmidt (1983). Farm management handbook of Kenya: Vol II. Ministry of Agriculture, Nairobi, Kenya, pp 311.

J. Kasina, J. Nderitu, G. Nyamasyo F. Olubayo, C. Waturu, E. Obudho and D. Yobera (2006). Diurnal Population Trends of *Megalurothrips sjotedti* and *Frankliniella occidentalis* (Thysanoptera: Thripidae) and their Natural Enemies on French Bean Phaseolus vulgaris (Fabaceae). *Interational J. of Insect Science*, **26**, pp 2-7.

W. D. J. Kirk (1997). Distribution, Abundance and Population Dynamics. **In** T. Lewis [ed.], *Thrips as crop pests.* CAB Oxon UK, pp 217-258.

E. Kuno (1991). Sampling and Analysis of Insect Populations. *Annu. Rev. Entomol.*, **36,** pp 285-304.

S. Michalik, A. A. Seif and A. M.Valera (2001). Integrated Pest Management. Manual for French beans. ICIPE, Nairobi, Kenya.

Ministry of Agriculture and JICA. (2002). Local and Export Vegetables Growing. 2nd ed. Agricultural Information Centre. Nairobi. Kenya.

North R. C. and Shelton A. M. (1986). Ecology of Thysanoptera within Cabbage Fields. *Environ. Entomol.*, **15**, pp 520-526.

J. M. Palmer, L. A. Mound and G. J. du Heauthe (1989). IIE Guides to Insects of *Importance to man 2. Thysanoptera.* CAB International Institute of Entomology, British Museum Natural History pp1-73.

A. B. Salifu and C. J. Hodgson (1987). Dispersion Patterns and Sequential Sampling Plans of *Megalurothrips sjostedti* Trybom (Thysanoptera: Thripidae) in Cowpeas. *Bull. Entomol. Res.* **77,** pp 441-449.

A.Seif A. M., Varela S. Michalik and B. Lohr (2001). A Guide to IPM in French Beans Production with Emphasis on Kenya: ICIPE Science Press. Nairobi, Kenya.

M. Y. Steiner (1990). Determining PopulationCharacteristics and Sampling Procedures for the Western Flower Thrips (Thysanoptera: Thripidae) and the Predatory Mite *Amblyseius cucumeris* (Acari: Phytoseiidae) on Greenhouse Cucumber. *Environ. Entomol.*, **19**, pp 1605-1613.

M.Tamo, J. Baumgartner and D. Y. Arodokoun (1993). The Spatio-temporal Distribution of *Megalurothrips sjostedti* Trybom (Thysanoptera: Thripidae) Life Stages on Cowpea, and Development of Sampling Plans. *Mitheilungen der Schweizerrischen Entomol. Gesellschaft,* **66**, pp 15-34.

L. R. Taylor (1961). Aggregation, Variance and the Mean. *Nature*, **189**, pp 732-735.

P. C. J. Van Rijn, C. Mollema and G. M. Steenhuis-Broers. (1995). Comparative Life History Studies of *Frankliniella occidentalis* and *Thrips tabaci* (Thysanoptera: Thripidae) on Cucumber. *Bull. Entomol. Res.*, **85**, pp 285-297.

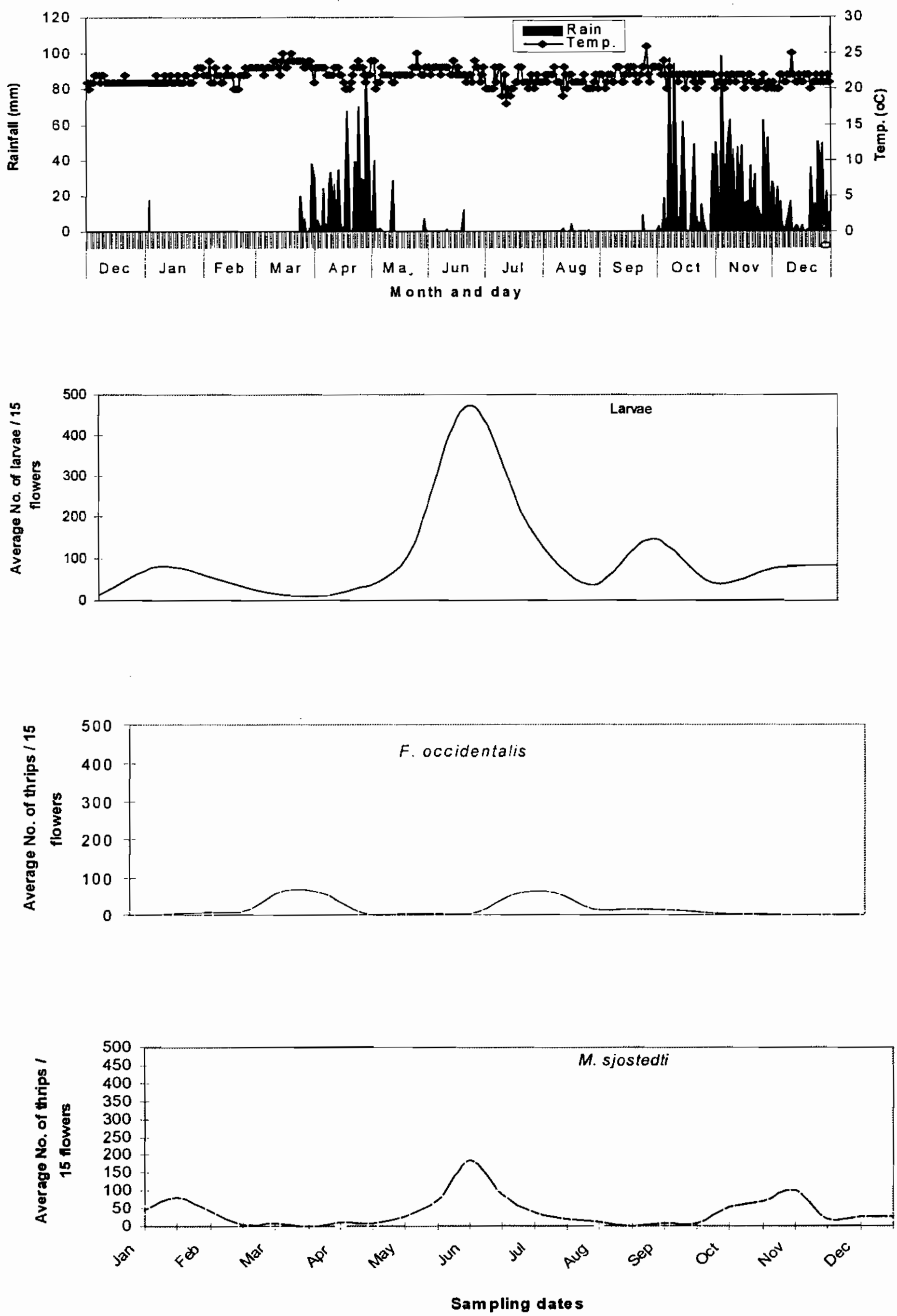

Figure 1: Relationships between weather parameters and seasonal population trends of thrips ;arvae amd adults of Megalurothrips sjostedti and Franklimiella occidentalis on French beans at Kaguru FTC

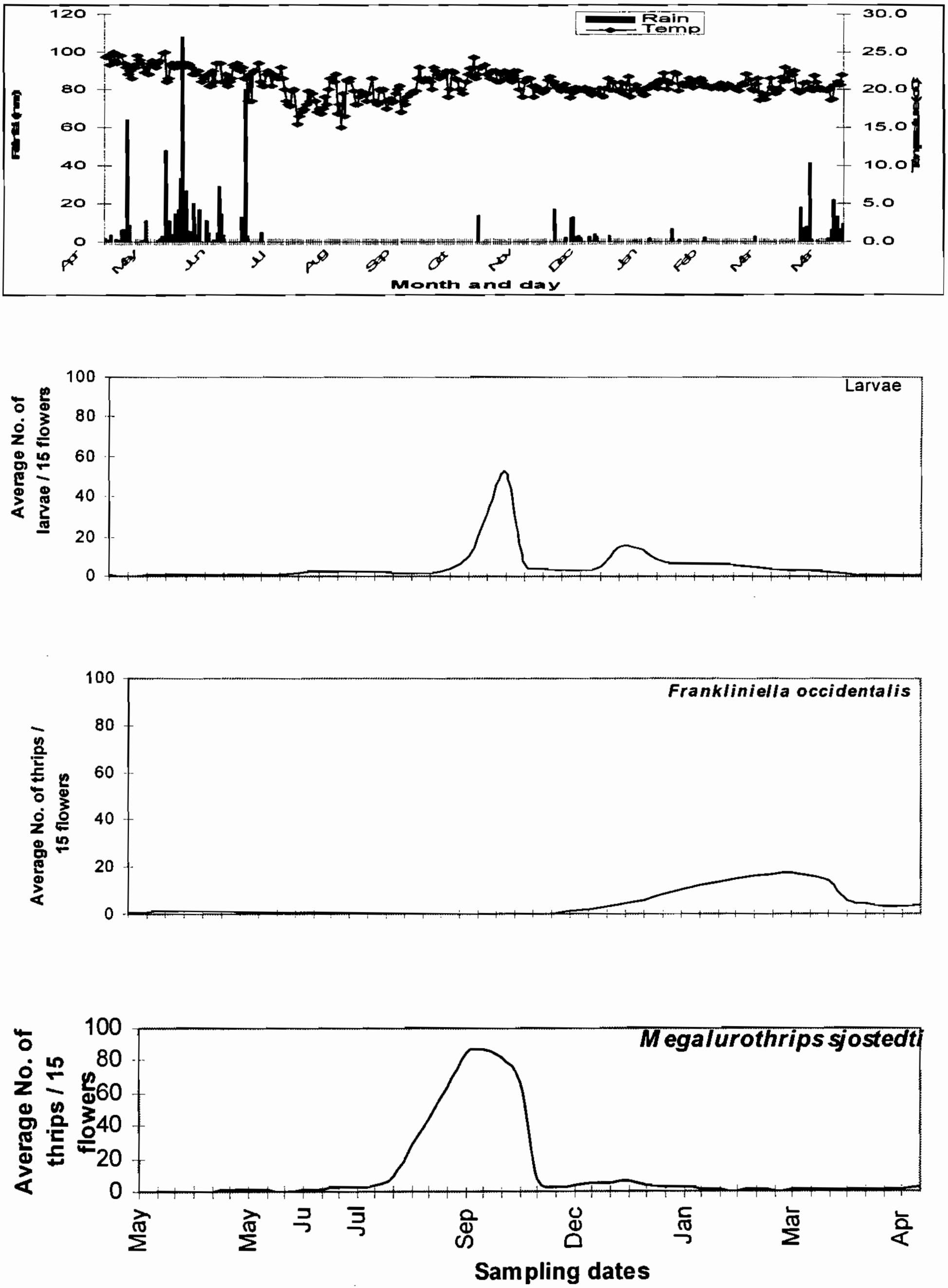

Figure 2: Relationships between weather parameters and seasonal population trends of thrips larvae. and adults of Megalurothrips sjostedti and Frankliniella occidentalis on French beans at JKUAT

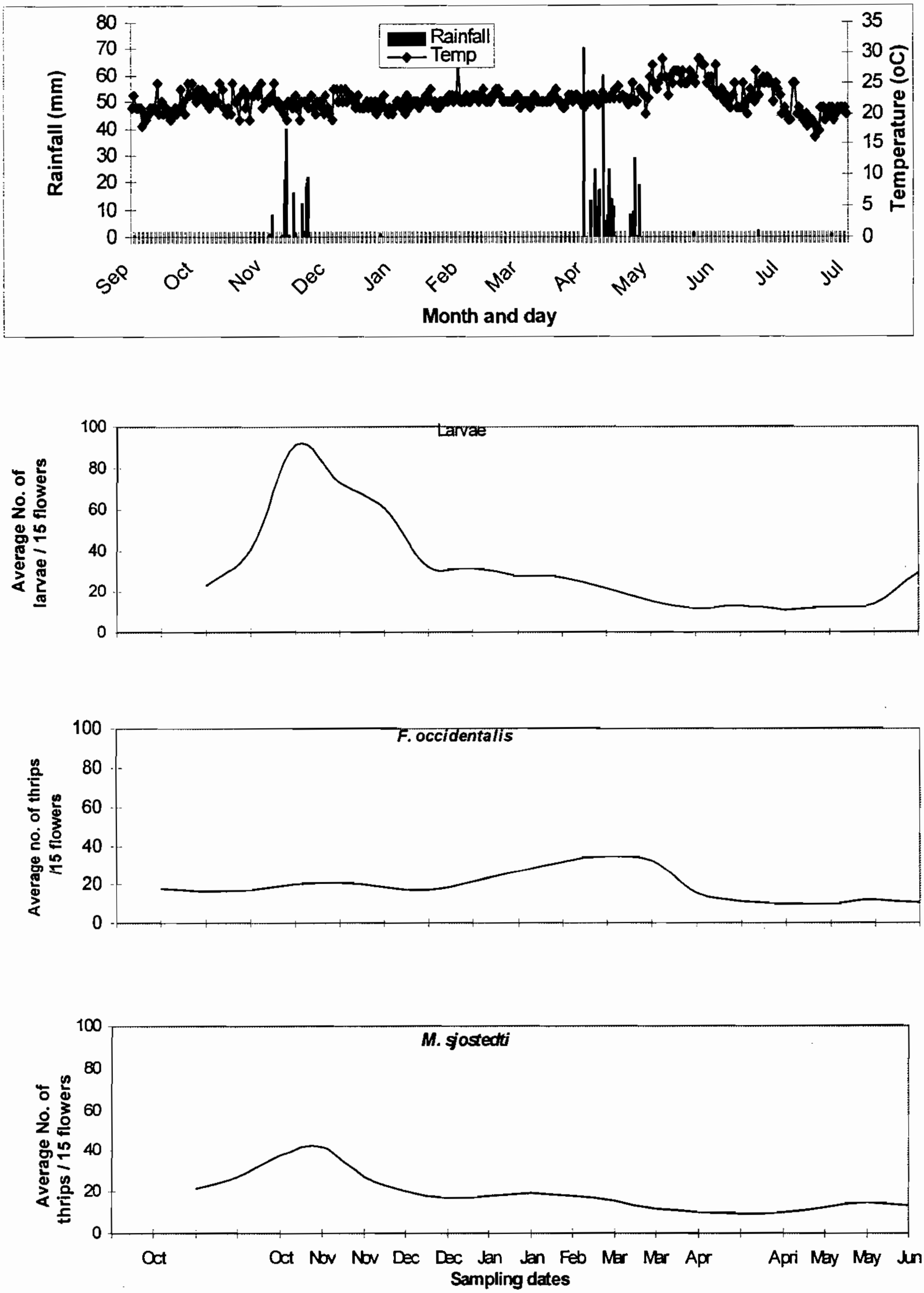

Figure 3: Relationships between weather parameters and seasonal population trends of thrips larvae and adults of Megalurothrips sjostedti and Frankliniella occidentalis of French beans at Machakos FTC

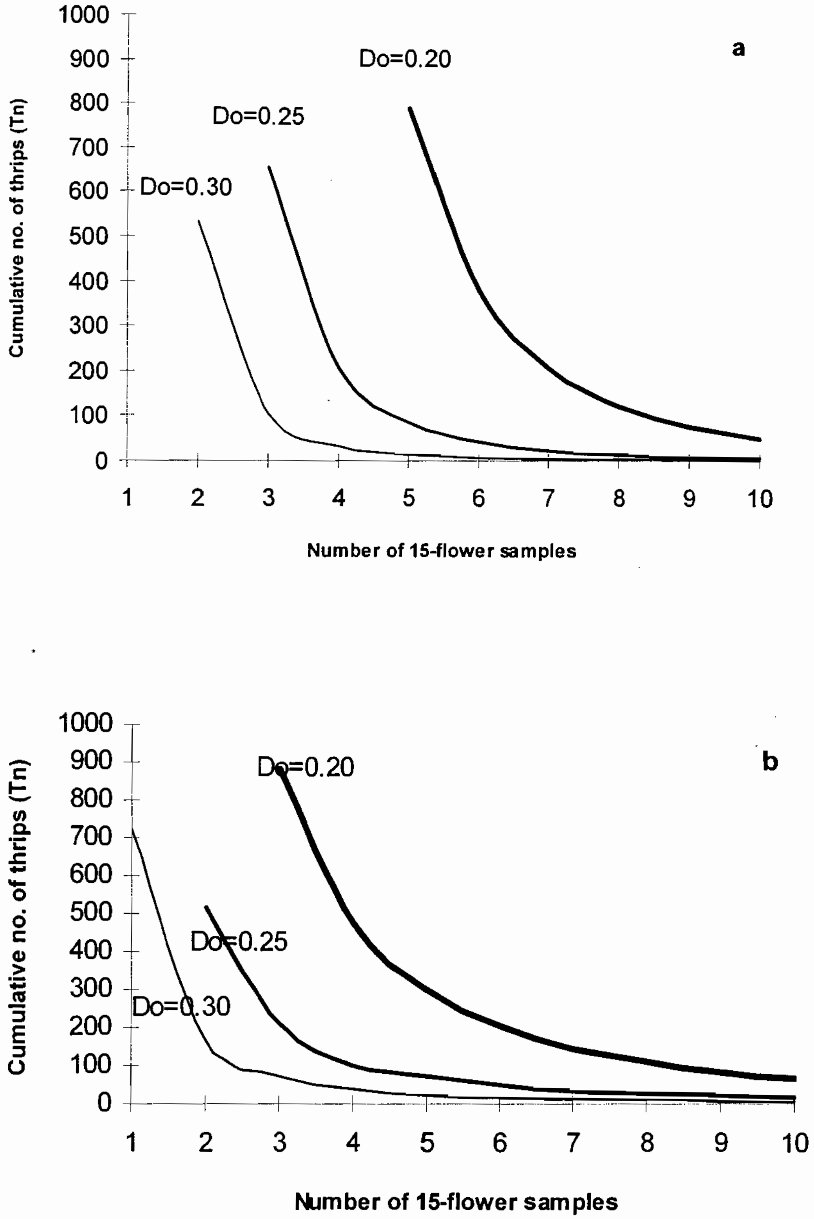

Figure 4: Sequence sampling stop lines for fixed-precision levels (Do) of 0.20, 0.25 and 0.30 for various densities of Frankliniella occidentalis (a) and Megalurothrips sjostedti (b) on the flowers of French beans

Table 1: Aggregation coefficients (b) of Tayor's power law function of Megalurothrips sjostedti, Frankliniella occidentalis and thrips larvae compared between flower buds, flowers and leaves of French beans at Machakos, Kaguru and JKUAT field sites

Variable	b±SE	R^2
Flower bud:		
Larvae	1.41± 0.04a*	0.96
F. occidentalis	1.30 ±0.17a	0.87
M. sjostedti	1.22 ±0.02a	0.93
Flower:		
Larvae	1.67± 0.02a	0.89
F. occidentalis	1.54 ±0.09a	0.73
M. sjostedti	1.45± 0.11a	0.85
Leaves:		
Larvae	1.42 ±0.04a	0.89
F. occidentalis	1.38 ±0.18a1	0.83
	Flower buds	
Flower buds		
Localities		
Machakos	1.38± 0.07a	0.95
Kaguru	1.23± 0.07a	0.96
Flower		
Machakos	1.57± 0.09a	0.88
Kaguru	1.55 ±0.10a	0.91
JKUAT	1.54± 0.12a	0.87
Leaves		
Machakos	1.47± 0.09a	0.98
Kaguru	1.33± 0.13a	0.92

For any group, means followed by the same letter are not significantly different ($P > 0.05$; Student-Newman-Keuls test).

Table 2: Coefficients of Taylor's power law function for adult Frankliniella occidentalis and Megalurothrips sjostedti and larvae in flower buds, flowers and leaves of French beans

Locality	Plant part	Thrips	n	log a ± se	b ± se	R^2	P>t(b>1)
JKUAT	Flower	*F. occidentalis*	44*	0.12 ±0.11	1.60±0.12	0.95	0.0001
		M. sjostedti	44	0.25±0.20	1.30±0.09	0.85	0.0001
		Larvae	44	0.15±0.19	1.71±0.21	0.95	0.0001
Machakosand Kaguru (pooled)	Flower	*F. occidentalis.*	43**	0.55± 0.16	1.80± 0.16	0.75	0.0001
		M.sjostedti	43	0.74±0.22	1.68± 0.18	0.69	0.0001
		Larvae	43	0.35± 0.31	1.84± 0.20	0.67	0.0001
	Flower bud	*F. occidentalis*	43	0.93 ±0.05	1.17± 0.13	0.67	0.0001
		M. sjostedti	43	0.62± 0.06	1.77± 0.16	0.76	0.0001
		Larvae	43	0.50± 0.16	1.81± 0.14	0.79	0.0001
Leaves		*F. occidentalis*		0.66± 0.10	1.84± 0.14	0.82	0.0001
		Larvae		0.55± 0.15	1.34± 0.18	0.78	0.0001

*Number of data points or sampling occasions.
** Number of data points (frequency) for pooled data from Machakos and Kaguru.