# Distribution and Relative Abundance of Bean Leaf Beetles (*Ootheca* spp.) (Insecta: Coleoptera: Chrysomelidae) in Uganda

Charles Halerimana[1,2], Samuel Kyamanywa[1], Samuel Olaboro[3], Pamela Paparu[3], Stanley T. Nkalubo[3], John Colvin[4], Robert A. Cheke[4], Thomas Wagner[5], Susan E. Seal[4], Darren J. Kriticos[6,7] and Michael H. Otim[3,*]

[1]Department of Agricultural production, College of Agricultural and Environmental Sciences, Makerere University, P.O.Box, 7062, Kampala, Uganda, chahalerimana@gmail.com (C.H); skyamanywa@gmail.com (S.K)

[2]National Coffee Research Institute, P.O.Box, 185, Mukono, Uganda, chahalerimana@gmail.com (C.H)

[3]National Crops Resources Research Institute, P.O.Box, 7084, Kampala, Uganda, motim9405@gmail.com (M.H.O); pamela.paparu@gmail.com (P.P); tamusange@gmail.com (S.T.N); olasamuel94@gmail.com(S.O)

[4]Natural Resources Institute, University of Greenwich at Medway, Central Avenue, Chatham Maritime, Kent ME4 4TB, United Kingdom, S.E.Seal@greenwich.ac.uk (S.E.S); J.Colvin@greenwich.ac.uk (J.C); R.A.Cheke@greenwich.ac.uk (R.A.C)

[5] Universität Koblenz-Landau, Institut für Integrierte Naturwissenschaften – Biologie, Universitätstrasse 1, 56070 Koblenz, Germany, thwagner@uni-koblenz.de (T.W)

[6] Commonwealth Scientific and Industrial Research Organization GPO 1700, Canberra, 2601, Australia, Darren.Kriticos@csiro.au (D.J.K)

[7] School of Biology, University of Queensland, 4072 Brisbane, Australia, Darren.Kriticos@csiro.au (D.J.K)

Corresponding author. Michael H. Otim

National Agricultural Research Organization

National Crops Resources Research Institute (NaCRRI) Namulonge

P.O. Box, 7084, Kampala, Uganda

Telephone: +256772897040

Email: motim9405@gmail.com

**Table S1.** Weather variables of the sampled agro-ecological zones during the sampling period [18].

| Season | Month | Northern Moist Farmlands | | | West Nile Farmlands | | | Central Wooded Savanna | | | Western Mid-Altitude Farmlands and the Semliki Flats | | | Southern and Eastern Lake Kyoga Basin | | | Southwestern Highlands | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Temp (°C) | R/H (%) | R/F (mm) | Temp (°C) | R/H (%) | R/F (mm) | Temp (°C) | R/H (%) | R/F (mm) | Temp (°C) | R/H (%) | R/F (mm) | Temp (°C) | R/H (%) | R/F (mm) | Temp (°C) | R/H (%) | R/F (mm) |
| 2016A | Apr | 25.0 | 71.0 | 219.7 | 24.3 | 67.5 | 234.0 | 23.7 | 72.5 | 122.2 | 22.2 | 85.5 | 168.8 | 24.8 | 65.0 | 178.3 | 19.5 | 85.5 | 199.0 |
| | May | 24.6 | 70.0 | 228.7 | 23.4 | 69.5 | 143.0 | 24.4 | 72.0 | 105.5 | 22.2 | 76.0 | 19.6 | 24.2 | 71.0 | 128.7 | 19.4 | 80.5 | 81.0 |
| | Jun | 24.5 | 66.0 | 92.4 | 23.0 | 68.0 | 68.4 | 22.8 | 66.0 | 61.9 | 21.6 | 65.5 | 18.7 | 24.2 | 64.0 | 63.6 | 18.0 | 74.0 | 33.0 |
| | Mean | 24.7 | 69.0 | 180.3 | 23.5 | 68.3 | 148.5 | 23.6 | 70.2 | 96.5 | 22.0 | 75.7 | 69.0 | 24.4 | 66.7 | 123.5 | 18.9 | 80.0 | 105.0 |
| 2016B | Jul | 23.5 | 71.5 | **204.3** | 22.0 | 74.0 | 173.7 | 22.1 | 71.0 | 71.1 | 21.9 | 66.5 | 6.2 | 23.6 | 67.0 | 32.3 | 18.0 | 68.5 | 19.0 |
| | Aug | 23.9 | 68.0 | 72.7 | 22.1 | 71.0 | 71.1 | 22.9 | 71.0 | 87.8 | 21.9 | 64.0 | 7.0 | 23.7 | 65.5 | 100.9 | 18.4 | 64.0 | 43.0 |
| | Sep | 23.9 | 65.0 | 119.6 | 22.4 | 70.5 | 171.5 | 22.8 | 71.5 | 142.7 | 21.9 | 67.0 | 29.6 | 24.0 | 62.0 | 121.2 | 19.1 | 71.5 | 184.0 |
| | Oct | 23.1 | 60.5 | 143.4 | 22.5 | 67.5 | 155.9 | 23.2 | 68.5 | 290.8 | 22.2 | 71.0 | 59.0 | 24.3 | 60.5 | 137.5 | 18.7 | 76.0 | 130.0 |
| | Nov | 23.7 | 59.0 | 59.3 | 23.0 | 63.5 | 98.4 | 23.7 | 67.0 | 101.6 | 22.0 | 79.0 | 112.1 | 24.4 | 57.5 | 134.3 | 18.3 | 79.5 | 124.0 |
| | Dec | 24.7 | 44.0 | 0.0 | 23.8 | 50.5 | 0.0 | 24.3 | 51.5 | 34.9 | 21.4 | 76.5 | 65.4 | 25.5 | 40.5 | 5.7 | 18.1 | 75.5 | 24.0 |
| | Mean | 23.8 | 61.3 | 99.9 | 22.6 | 66.2 | 111.8 | 23.1 | 66.8 | 121.5 | 21.9 | 70.7 | 46.6 | 24.3 | 58.8 | 88.7 | 18.4 | 72.5 | 87.0 |
| 2017A | Jan | 26.7 | 32.5 | 3.3 | 25.0 | 42.0 | 1.0 | 25.3 | 43.5 | 6.1 | 21.1 | 67.5 | 52.3 | 26.3 | 41.0 | 18.9 | 18.7 | 69.5 | 41.0 |
| | Feb | 26.6 | 46.0 | 34.6 | 25.3 | 48.0 | 14.3 | 25.5 | 54.0 | 92.8 | 23.1 | 77.5 | 132.0 | 26.1 | 49.5 | 147.2 | 18.4 | 77.0 | 50.0 |
| | Mar | 26.3 | 62.5 | 181.8 | 25.5 | 54.5 | 99.7 | 25.0 | 59.5 | 112.5 | 22.3 | 79.5 | 166.8 | 25.2 | 60.0 | 90.4 | 18.3 | 80.5 | 115.0 |
| | Apr | 26.4 | 60.5 | 151.9 | 24.2 | 62.5 | 129.4 | 24.8 | 63.5 | 113.3 | 22.0 | 81.0 | 154.6 | 25.1 | 60.0 | 155.7 | 18.1 | 81.0 | 72.0 |
| | May | 25.1 | 70.5 | 138.1 | 23.4 | 67.0 | 128.0 | 24.1 | 69.0 | 130.6 | 21.8 | 83.0 | 93.8 | 23.4 | 70.0 | 150.6 | 17.9 | 80.5 | 76.0 |
| | Jun | 25.4 | 66.5 | 166.1 | 22.9 | 69.0 | 146.4 | 23.7 | 68.5 | 253.1 | 20.5 | 75.5 | 20.1 | 23.9 | 65.5 | 55.1 | 18.0 | 70.0 | 5.0 |
| | Mean | 26.1 | 56.4 | 112.6 | 24.4 | 57.2 | 86.5 | 24.7 | 59.7 | 118.1 | 21.8 | 77.3 | 103.3 | 25.0 | 57.7 | 102.9 | 18.2 | 76.4 | 60.0 |

Key: 2016A = 2016 first rains, 2016B = 2016 second rains, 2017A = 2017 first rains. Temp = temperature, R/F = rainfall, R/H = relative humidity. Temperatures presented are the averages of maximum and minimum temperatures of each month. Relative humidity presented is the average of humidity at 9 am and 3pm for each month.

**Table S2.** The breakdown of genera or species categorized under others in Table 2

| Genera/Species | Agro-ecological zone | | | | | | Mean |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | NMF | WNF | CWS | WFL | SWH | SEK | |
| *Buphonella* | 0 | 0 | 6.1 | 0 | 0 | 0 | 1.0 |
| *Parasbecesta ruwensorica* | 0.8 | 1.4 | 0 | 0 | 0 | 0 | 0.4 |
| *Exosoma pecipenis* | 0 | 1.2 | 0 | 1.2 | 0 | 0 | 0.4 |
| *Neobarombiella* | 0 | 0 | 3.8 | 0 | 0 | 0 | 0.6 |
| *Afrophthalma* | 0 | 0 | 2.6 | 0.6 | 0 | 0 | 0.5 |
| *Chrysochrus* | 0.6 | 0.08 | 0 | 0 | 0 | 0 | 0.1 |
| *Exosoma* | 0 | 1.2 | 0 | 0.8 | 0 | 0 | 0.3 |
| *Lamprocopa* | 0.06 | 3.0 | 0 | 0.6 | 0 | 0 | 0.6 |
| *Plagiodera* | 0.5 | 0 | 0 | 0 | 0 | 0 | 0.08 |

Key: NMF = Northern Moist Farmlands, WNF = West Nile Farmlands, CWS = Central Wooded Savanna, WFL = Western Mid-Altitude Farmlands and the Semliki Flats, SWH = Southwestern Highlands, SEK = Southern and Eastern Lake Kyoga Basin

**Table S3.** Foliar damage due to bean leaf beetles across seasons

| Season | Foliar damage per plant (±SE) |
| --- | --- |
| 2016 first rains | 0.87±0.05a |
| 2016 second rains | 0.79±0.03a |
| 2017 first rains | 0.87±0.04a |

Within a column, values bearing the same letter are not significantly different at $p = 0.05$

**Table S4.** Influence of different bean growth stages and reproductive phases (abbreviations are listed in Figure 7) on bean leaf beetle populations in Uganda

| Bean growth stage | Bean leaf beetles per plant (±SE) |
| --- | --- |
| V1 | 0.09±0.02a |
| V2 | 0.10±0.03a |
| V3 | 0.07±0.02a |
| V4 | 0.09±0.02a |
| V5 | 0.05±0.02a |
| R1 | 0.13±0.03a |
| R2 | 0.11±0.03a |
| R3 | 0.11±0.03a |
| R4 | 0.04±0.02a |
| R5 | 0.04±0.01a |
| R6 | 0.05±0.02a |

Within a column, values bearing the same letter are not significantly different at $p = 0.05$

**Table S5.** Influence of cropping systems on foliar damage in different agro-ecological zones in Uganda.

| Agro-ecological zone | Foliar damage per plant (±SE) | |
|---|---|---|
| | Monocrop | Intercrop |
| Northern Moist Farmlands | 1.12±0.07de | 1.19±0.04e |
| West Nile Farmlands | 0.85±0.07bcd | 0.95±0.05cde |
| Central Wooded Savanna | 0.80±0.11bcde | 0.89±0.06cd |
| Western Mid-Altitude Farmlands and the Semliki Flats | 0.21±0.11a | 0.55±0.06ab |
| Southwestern Highlands | 0.52±0.08ab | 0.54±0.07ab |
| Southern and Eastern Lake Kyoga Basin | 0.76±0.09bcd | 0.69±0.07bc |

Within a row, values bearing the same letter or letter combinations are not significantly different at $p = 0.05$


**Table S6.** Influence of host plant density on bean leaf beetle populations and foliar damage across agro-ecological zones

| Agro-ecological zone | Bean leaf beetles per plant (±SE) | | Foliar damage per plant (±SE) | |
|---|---|---|---|---|
| | Low density | High density | Low density | High density |
| Northern Moist Farmlands | 0.14±0.01b | 0.20±0.06ab | 1.15±0.04e | 1.40±0.16de |
| West Nile Farmlands | 0.04±0.01a | 0.05±0.07ab | 0.92±0.04cd | 0.90±0.18abcde |
| Central Wooded Savanna | 0.08±0.02ab | 0.08±0.12ab | 0.87±0.05cd | 1.02±0.31abcde |
| Western Mid-Altitude Farmlands and the Semliki Flats | 0.07±0.02ab | 0.25±0.17ab | 0.46±0.05a | 0.75±0.43abcde |
| Southwestern Highlands | 0.02±0.02a | 0.00±0.12ab | 0.54±0.05ab | 0.33±0.30abcde |
| Southern and Eastern Lake Kyoga Basin | 0.09±0.02ab | 0.00±0.06ab | 0.75±0.05bc | 0.43±0.17abc |

Within a row, values bearing the same letter or letter combinations are not significantly different at $p = 0.05$ for each category


**Table S7.** Effect of time of sampling on occurrence of bean leaf beetles

| Time of sampling | Bean leaf beetles per plant (±SE) |
|---|---|
| Early morning hours (8-11 a.m.) | 0.06±0.01a |
| Afternoon hours (12-3 p.m.) | 0.09±0.27a |
| Evening hours (4-5 p.m.) | 0.10±0.01a |

Within a column, values bearing the same letter are not significantly different at $p = 0.05$

**Table S8.** Influence of crop history on bean leaf beetle populations and foliar damage across agro-ecological zones

| Agro-ecological zone | Bean leaf beetles per plant (±SE) | | Foliar damage per plant (±SE) | |
|---|---|---|---|---|
| | Host | Non-host | Host | Non-host |
| Northern Moist Farmlands | 0.14±0.03ab | 0.14±0.01b | 1.12±0.08de | 1.18±0.04e |
| West Nile Farmlands | 0.03±0.04ab | 0.04±0.02a | 1.12±0.11de | 0.88±0.04cd |
| Central Wooded Savanna | 0.05±0.05ab | 0.09±0.02ab | 0.71±0.12abcd | 0.91±0.06cd |
| Western Mid-Altitude Farmlands and the Semliki Flats | 0.03±0.03ab | 0.11±0.03ab | 0.34±0.08a | 0.57±0.08ab |
| Southwestern Highlands | 0.05±0.03ab | 0.02±0.02a | 0.51±0.09ab | 0.55±0.06ab |
| Southern and Eastern Lake Kyoga Basin | 0.06±0.03ab | 0.09±0.02ab | 0.61±0.09abc | 0.78±0.07bcd |

Within a row, values bearing the same letter or letter combinations are not significantly different at $p = 0.05$ for each category

**Table S9.** Influence of insecticide use history on bean leaf beetle populations and foliar damage across agro-ecological zones

| Agro-ecological zone | Bean leaf beetles per plant (±SE) | | Foliar damage per plant (±SE) | |
|---|---|---|---|---|
| | Used | Not used | Used | Not used |
| Northern Moist Farmlands | 0.10±0.02ab | 0.16±0.01b | 1.21±0.07ef | 1.15±0.04df |
| West Nile Farmlands | 0.04±0.04ab | 0.04±0.01a | 0.91±0.11bcdef | 0.92±0.04ce |
| Central Wooded Savanna | 0.01±0.06ab | 0.09±0.02ab | 0.60±0.16abcd | 0.91±0.06cdef |
| Western Mid-Altitude Farmlands and the Semliki Flats | 0.00±0.07ab | 0.08±0.02ab | 0.60±0.19abcdef | 0.45±0.05a |
| Southwestern Highlands | 0.05±0.06ab | 0.02±0.02a | 0.67±0.17abcdef | 0.52±0.05ab |
| Southern and Eastern Lake Kyoga Basin | 0.08±0.03ab | 0.09±0.02ab | 0.77±0.09abc | 0.69±0.07abc |

Within a row, values bearing the same letter or letter combinations are not significantly different at $p = 0.05$ for each category

Table S10. Potential non-crop hosts of bean leaf beetles and their host agro-ecological zones

| Number | Species/subspecies name | Family name | Life form | Host agro-ecological zone |
|---|---|---|---|---|
| 1 | *Abelmoschus esculentus* (L.) Moench | Malvaceae | herb | NMF, WNF |
| 2 | *Abutilon hirtum* (Lam.) Sweet | Malvaceae | herb | NMF, SEK, WNF, CWS, SWH, WFL |
| 3 | *Abutilon mauritanum* (Jacq.) Medik. | Malvaceae | herb | NMF, SEK, WNF, CWS, SWH, WFL |
| 4 | *Acalypha crenata* Hochst. ex A. Rich. | Euphorbiaceae | herb | NMF |
| 5 | *Acanthospermum hispidum* DC. | Asteraceae | herb | NMF |
| 6 | *Amaranthus dubius* Mart. ex Thell. | Amaranthaceae | herb | NMF, SEK, WNF, CWS, SWH, WFL |
| 7 | *Amaranthus hybridus cruentus* (L.) Thell. | Amaranthaceae | herb | NMF, SEK, WNF, CWS, SWH, WFL |
| 8 | *Aspilia kotschyi* (Sch. Bip. ex Hochst.) Oliv. | Asteraceae | herb | NMF, NWF |
| 9 | *Asystasia gangetica* (L.) T. Anderson | Acanthaceae | herb | NMF |
| 10 | *Asystasia mysorensis* (Roth) T. Anderson | Acanthaceae | herb | NMF, SEK |
| 11 | *Celosia trigyna* L. | Amaranthaceae | herb | NMF, SEK, WNF |
| 12 | *Clerodendrum umbellatum* Poir. | Verbanaceae | herb | NMF |
| 13 | *Combretum collinum* Fresen. | Combretaceae | tree | NMF |
| 14 | *Corchorus olitorius* L. | Tiliaceae | herb | NMF, WNF |
| 15 | *Crossandra subacaulis* C. B. Clarke | Acanthaceae | herb | NMF, CWS |
| 16 | *Crotalaria* sp. | Papilionaceae | herb | NMF, SEK, WFL |
| 17 | *Cyathula prostrata* (L.) Blume | Amaranthaceae | herb | NMF, SEK |
| 18 | *Desmodium gangeticum* (L.) DC. | Papilionaceae | herb | NMF, WNF |
| 19 | *Desmodium tortuosum* (Sw.) DC. | Papilionaceae | herb | NMF, SEK, WNF |
| 20 | *Dombeya burgessiae* Gerrard ex Harv. | Sterculiaceae | shrub | WFL |
| 21 | *Dyschoriste nagchana* (Nees) Bennet | Acanthaceae | herb | NMF, SEK, WFL |
| 22 | *Erlangea cordifolia* (Benth. ex Oliv.) S. Moore | Asteraceae | herb | NMF |
| 23 | *Grewia mollis* Juss. | Tiliaceae | shrub | NMF |
| 24 | *Hibiscus acetosella* Welw. ex Hiern. | Malvaceae | herb | NMF, SEK, WNF |
| 25 | *Abelmoschus moschatus* Medik. | Malvaceae | herb | NMF, WNF |
| 26 | *Kosteletzkya adoensis* (Hochst. ex A. Rich.) Mast. | Malvaceae | herb | NMF, SEK, SWH |
| 27 | *Leonotis nepetifolia* (L.) R. Br. | Lamiaceae | herb | NMF |
| 28 | *Lipia abyssinica* (Otto & A. Dietr.) Cufod. | Verbenaceae | herb | NMF, SEK, WNF, CWS |
| 29 | *Lippia woodii* Mold. | Verbenaceae | herb | NMF |

| Number | Species/subspecies name | Family name | Life form | Host agro-ecological zone |
|---|---|---|---|---|
| | **Table S10** *Cont.* | | | |
| 30 | *Micrococca merculiaris* (L.) Benth. | Euphorbiaceae | herb | NMF |
| 31 | *Oxygonum sinuatum* (Hochst. & Steud. ex Meisn.) Dammer | Polygonaceae | herb | NMF |
| 32 | *Philenoptera laxiflora* (Guill. & Perr.) Roberty | Papilionaceae | tree | NMF |
| 33 | *Senna obtusifolia* (L.) H. S. Irwin & Barneby | Caesalipinaceae | herb | NMF |
| 34 | *Sida alba* L. | Malvaceae | herb | NMF, SEK, WNF, CWS, SWH, WFL |
| 35 | *Sida rhombifolia* L. | Malvaceae | herb | NMF, SEK, WNF, CWS, SWH, WFL |
| 36 | *Synerdrella nodiflora* L. (Gaertn.) | Asteraceae | herb | NMF, SEK |
| 37 | *Trichodesma zeylanicum* (Burm. f.) R. Br. | Boraginaceae | herb | NMF |
| 38 | *Triumfetta macrophylla* K. Schum. | Tiliaceae | herb | NMF, SEK, WNF, CWS, SWH, WFL |
| 39 | *Triumfetta rhomboidea* Jacq. | Tiliaceae | herb | NMF, SEK, WNF, CWS, SWH, WFL |
| 40 | *Urena lobata* L. | Malvaceae | herb | NMF, SEK, WNF, CWS, SWH, WFL |
| 41 | *Vernonia cinerea* (L.) Less. | Asteraceae | herb | NMF, SEK |

Key: NMF = Northern Moist Farmlands, WNF = West Nile Farmlands, CWS = Central Wooded Savanna, WFL = Western Mid-Altitude Farmlands and the Semliki Flats, SWH = Southwestern Highlands, SEK = Southern and Eastern Lake Kyoga Basin