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Insects associated with fruits of the Oleaceae (Asteridae, Lamiales) in Kenya, with special reference to the Tephritidae (Diptera)

Robert S. Copeland
Department of Entomology, Texas A&M University, College Station, Texas 77843 USA, and International Centre of Insect Physiology and Ecology, Box 30772, Nairobi, Kenya; email: hunteriazeylanica@yahoo.com

Ian M. White
Department of Entomology, The Natural History Museum, Cromwell Road, London, SW7 5BD, UK; e-mail: imw@nhm.ac.uk

Millicent Okumu, Peris Machera
International Centre of Insect Physiology and Ecology, Box 30772, Nairobi, Kenya.

Robert A. Wharton
Department of Entomology, Texas A&M University, College Station, Texas 77843 USA; e-mail: rawbaw2@neo.tamu.edu

Abstract

Collections of fruits from indigenous species of Oleaceae were made in Kenya between 1999 and 2003. Members of the four Kenyan genera were sampled in coastal and highland forest habitats, and at altitudes from sea level to 2979 m. *Schrebera alata*, whose fruit is a woody capsule, produced Lepidoptera only, as did the fleshy fruits of *Jasminum* species. Tephritid fruit flies were reared only from fruits of the oleaceous subtribe Oleinae, including *Olea* and *Chionanthus*. Four tephritid species were reared from *Olea*. The olive fly, *Bactrocera oleae,* was found exclusively in fruits of *O. europaea* ssp. *cuspidata,* a close relative of the commercial olive, *Olea europaea* ssp. *europaea*. Olive fly was reared from 90% (n = 21) of samples of this species, on both sides of the Rift Valley and at elevations to 2801 m. *Bactrocera munroi*, **sp. nov**. was reared from both *O. europaea* ssp. *cuspidata* and *Olea welwitschii*. *B. munroi* is only the second *Bactrocera* species to be reared from *O. europaea* s.l. *Bactrocera biguttula* and *Ceratitis capitata* were reared from the coastal olive, *Olea woodiana* ssp. *disjuncta*. A new species of adramine tephritid*, Munromyia whartoni* **sp. nov**., was reared from *Chionanthus niloticus* in western Kenya. Opiine braconid parasitoids were reared from *M. whartoni* and *B. oleae*. The former was attacked by a single species of *Psyttalia*, while the latter was parasitized by *Psyttalia concolor*, *Psyttalia lounsburyi* and *Utetes africanus*. In some collections, rates of parasitization of olive fly by *P. lounsburyi* exceeded 30%. Moths and several of their parasitoids were reared from all four genera of Oleaceae. Species richness of moths in oleaceous fruits was about twice that of tephritids.

The subgenus *Afrodacus* Bezzi is proposed as a new synonym of subgenus *Daculus* Speiser, and all Asian species previously placed in subgenus *Afrodacus* are transferred to subgenus *Bactrocera*. Descriptions of 2 new species of Tephritidae, a key to the species of *Munromyia*, and a synopsis (with key to species) of African *Bactrocera* subgenus *Daculus* are provided.

Introduction

The family Oleaceae, although concentrated primarily in southeast Asia and Australasia, is found in diverse tropical and temperate regions of the world and has a nearly cosmopolitan distribution (Heywood, 1998). Recently, Wallander & Albert (2000) used chloroplast DNA sequences from species representing all known oleaceous genera to construct a phylogeny of the family. They rejected a subfamilial classification (e.g., Johnson, 1957) of the Oleaceae after showing that the Jasminoideae were paraphyletic. Instead they proposed a tribe-based higher classification and it is their interpretation of Oleaceae phylogeny that we follow in this paper.

In Kenya, the family is poorly represented, having only 4 of the 25 currently recognized genera. Three of the indigenous genera (*Olea* L. and *Chionanthus* L. [Oleeae: Oleinae] and *Jasminum* L. [Jasmineae]) have representatives that are widely distributed in Kenya: from coastal lowlands to western highlands and at altitudes from sea level to ca. 3000 m, primarily in woodland (*sensu* Greenway, 1973) and forest habitats (Beentje, 1994). The other Kenyan genus, *Schrebera* Roxb. (Oleeae: Schreberinae), is represented by a single species and confined to upland dry forest (Beentje, 1994). While *Schrebera alata* (Hochst.) Welw. produces a dry capsule, *Chionanthus* (drupe), *Olea* (drupe), and *Jasminum* (berry) all produce fleshy fruits. The genus *Olea* has recently been revised (Green, 2002) and we follow this classification.

Among the oleaceous plants, only cultivars of *Olea europaea* L. ssp. *europaea* produce economically important fruits. It is the source of edible olives and olive oil and a major commercial crop in subtropical areas of the world with a Mediterranean climate, particularly in southern Europe and the Levant. Commercial olives are also cultivated extensively in South Africa and California. Commercial olive is thought to be derived from *Olea europaea* L. ssp. *cuspidata* (Wall ex G. Don) (Mabberly, 1998). The similarity of *Olea europaea* L. ssp. *africana* (Mill.) P. S. Green, the other previously recognized indigenous sub-Saharan member of *O. europaea*, to *O. europaea* ssp. *cuspidata* has long been recognized, and recently they have been placed in synonymy (Green, 2002), with *O. europaea* ssp. *cuspidata* having priority.

In many parts of Mediterranean Africa and Europe, *Bactrocera oleae* (Rossi) is the most important pest of cultivated olives (Mustafa & Al-Zaghal, 1987), and efforts to find natural enemies of *B. oleae* span nearly a century (Silvestri, 1913; Raspi, 1993; Purcell, 1998). Several species of parasitic wasps have been introduced into southern Europe in an effort to control *B. oleae* (Silvestri, 1913; Greathead, 1976; Wharton, 1989). Of these, a measure of success has been seen only with *Psyttalia concolor* (Szépligeti) which became established, but in low densities, following its release in Italy before and after World War I (Monastero, 1931; Silvestri, 1939; Raspi, 1993). Augmentative releases of laboratory-reared *P. concolor* have been used for more than 50 years to help control populations of *B. oleae* (Raspi, 1993; Raspi & Loni, 1994; Kennett *et al.*, 1999). Yet olive losses continue to plague growers (Raspi *et al.*, 1996), and introductions of *P. concolor* have failed in several other regions of Europe (Clausen, 1978; Loni, 1997), possibly due, at least in part, to climatic factors (Raspi & Loni, 1994).

Bactrocera oleae occurs widely throughout eastern and southern Africa, attacking fruits of *O. europaea* ssp. *cuspidata*, and the potential benefit of exploration in sub-Saharan Africa for natural enemies of *B. oleae* has long been recognized (Silvestri, 1913, 1914, 1916). Silvestri collected 14 species of parasitic wasps from fruits infested with *B. oleae* in Eritrea in 1914, and returned to Italy with 10 of them. Although none of these became established after release (Neuenschwander, 1982; Wharton, 1989), *P. concolor*, as noted above, was repeatedly released and eventually became established. With the realization that neither native natural enemies nor *P. concolor* was providing satisfactory control in most areas, interest in obtaining new natural enemies was revived in the 1970s. A single expedition to Ethiopia and Kenya was made in 1975 by Greathead (1976) to collect parasitoids of olive fly. However, no fruiting specimens of *Olea* species were encountered in Kenya and searches in Ethiopia produced meager results. Neuenschwander (1982) was much more successful in his search for olive fly parasitoids in South Africa, but unfortunately the material shipped to Europe could not be cultured and thus no species were established.

In this paper we report on the insects reared from oleaceous fruits collected during a widespread survey of insects of wild fruits of Kenya conducted from 1999 to 2003. We focus special attention on the tephritids and their parasitoids recovered from native olive species, given the recent introduction of olive fly to California and the concomitant interest in reviving a classical biological control program for this pest (Collier & Van Steenwyk, 2003).

Materials and Methods

For the overall survey of indigenous fruits, sites were chosen to ensure extensive sampling of major woodland and forest habitats both east of the Gregory Rift Valley (coastal forests, mid-altitude for-

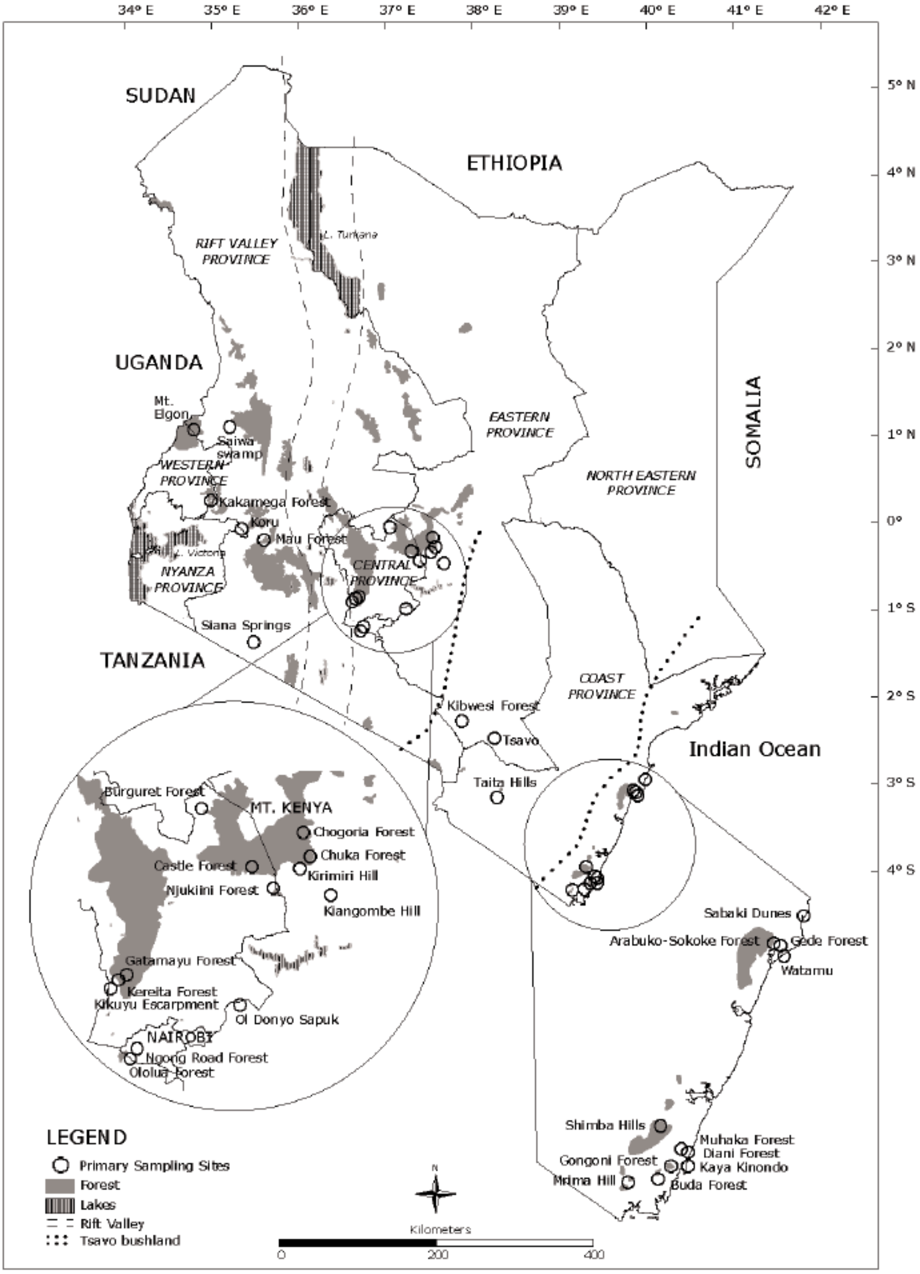

Figure 1. Collecting sites in Kenya.

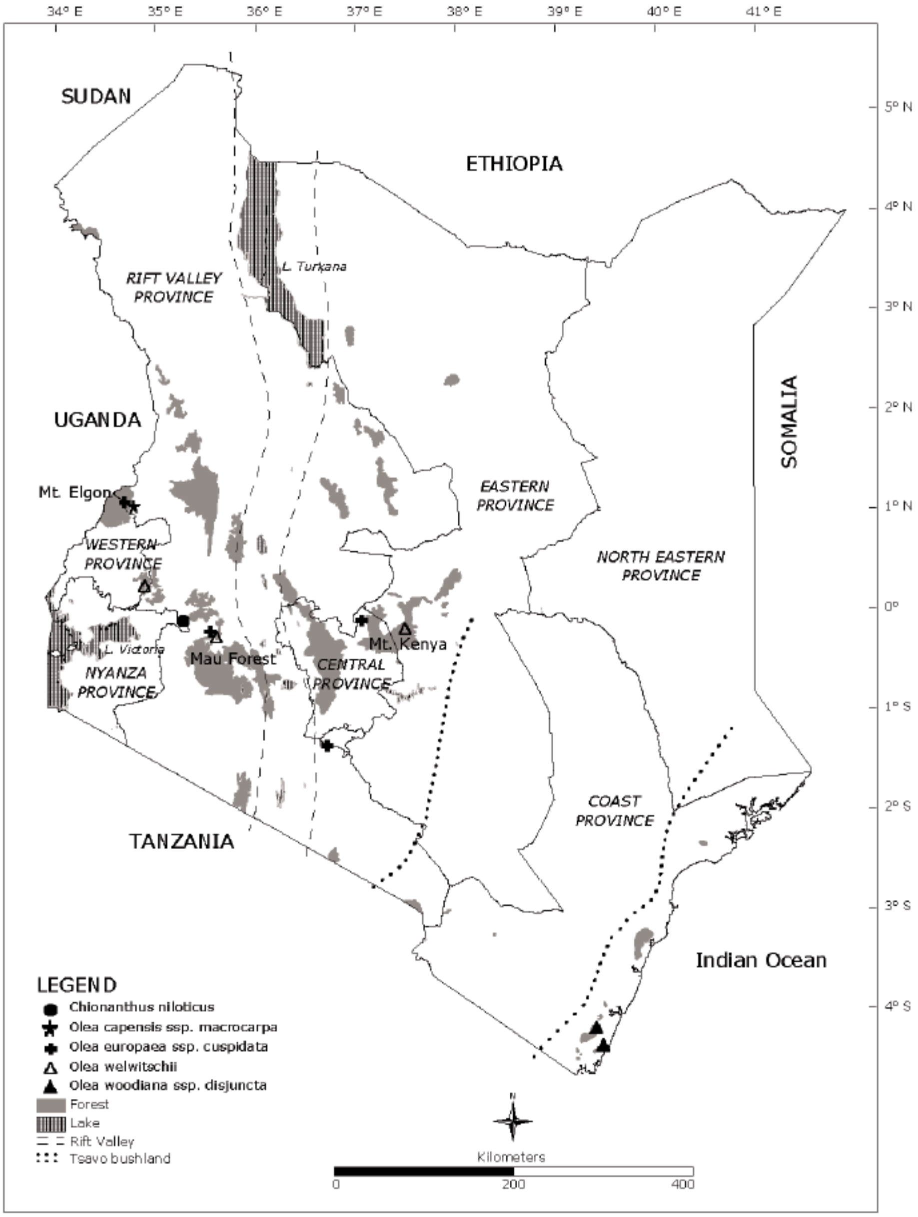

Figure 2. Collection locations of *C. niloticus* and *Olea* species in Kenya.

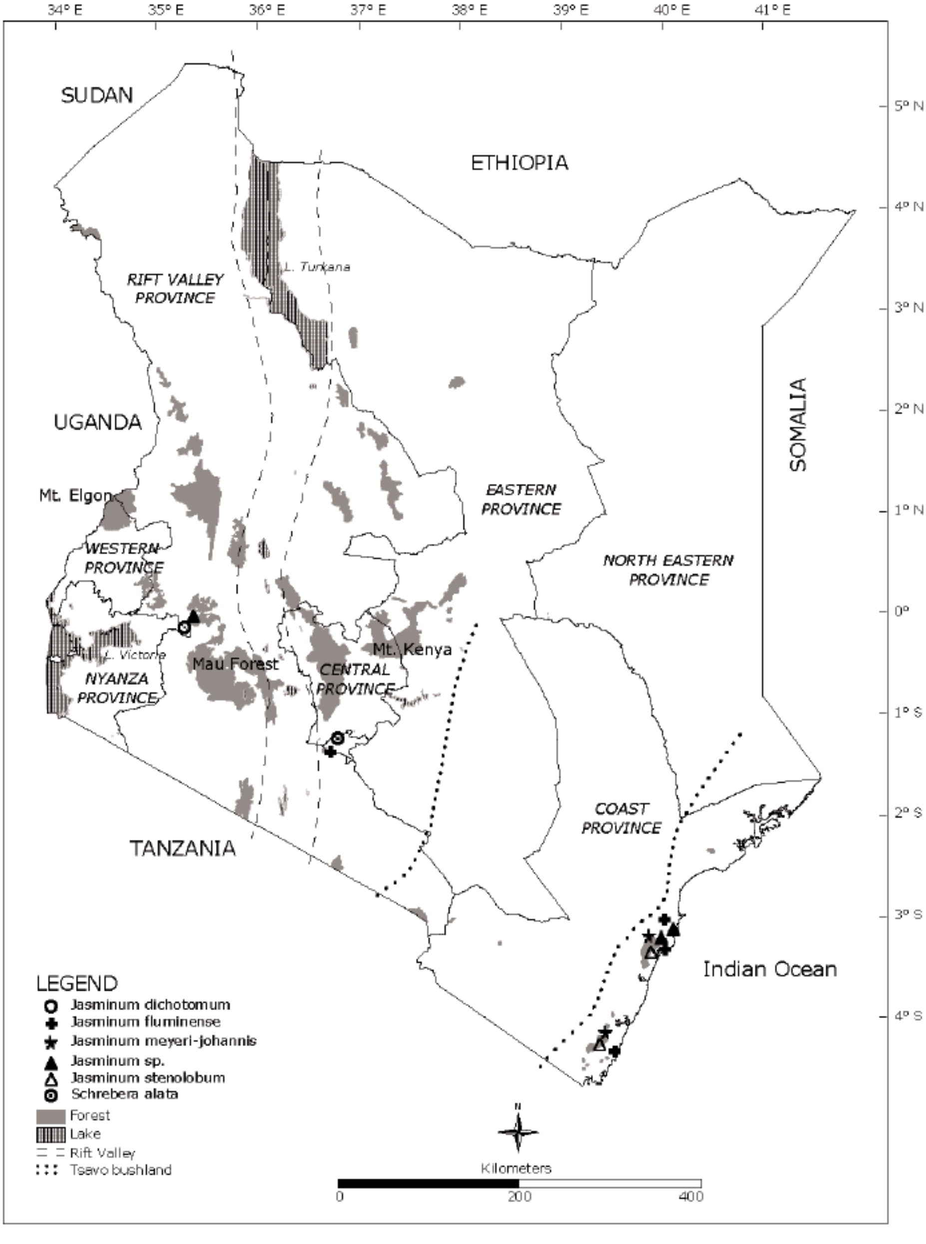

Figure 3. Collection locations of *Jasminum* species and *Schrebera alata* in Kenya.

Table 1. Collections of Oleaceae[1]

Tribe	Subtribe	Plant species	No. of collections	No. of fruits collected	Total weight (gm)	Months collected	Region collected[2]	Altitudinal range (m)
Jasmineae		*Jasminum dichotomum* Vahl	3	315	130	1,2	we	1460–1565
		Jasminum fluminense Vell.	5	918	239	1,4,8,10,11	ce,co	24–1750
		Jasminum meyeri-johannis Engl.	3	1,260	631	7,8	co	55–270
		Jasminum L. sp.	3	494	197	7,8,9	co,we	10–1574
		Jasminum stenolobum Rolfe	2	1,049	520	4,7	co	55–436
Oleeae	Oleinae	*Chionanthus niloticus* (Oliv.) Stearn	3	1,958	1,325	6,7,8	we	1565
		Olea capensis L. ssp. *macrocarpa* (C. H. Wright) I. Verd.	1	155	123	2	we	2234
		Olea europaea L ssp. *cuspidata* (G. Don.) Cif.	21	28,625	7,312	1,2,3,4,5,8,9,11	ce,we	1706–2979
		Olea welwitschii (Knobl.) Gilg & Schnellenb.	8	7,287	2,921	6,8,9	ce,we	1550–2448
		Olea woodiana Knobl. ssp. *disjuncta* P. S. Green	2	758	424	7,8	co	5–201
	Schreberinae	*Schrebera alata* Welw.	2	167	316	4	ce	1759–1889
		Totals	53	42,986	14,138			

1. Higher classification based on Wallander & Albert (2000).

2. ce = central highlands, co = coastal lowlands, we = western highlands.

est, high altitude dry and wet forest), and west of it (high altitude wet forest). Sites included those reported earlier (Copeland *et al.*, 2002) with some important additions (Fig. 1). Central highland forests are separated by the Gregory Rift Valley from forests of the western highlands, while coastal forests are isolated from both by a broad swath of xeric "Tsavo bushland" (Lind & Morrison, 1974) [= "dry scrub with trees", (Greenway, 1974)] (Fig. 1). In addition to forests, fruits were sampled in other habitats, particularly open woodland in highland areas, and shrubland, dune, coral-rag associations, and open woodland at the coast. GPS data were recorded at the site of each collection or at the nearest opening if the fruits were collected in dense forest.

Monthly collections were made from February 1999 through January 2003 at sites in western, central, and eastern Kenya. Details of the collection and handling of fruit samples are provided in Copeland *et al.* (2002). Additionally, in order to determine whether differences in developmental stages of fruit influenced the infestation rate in olives, we made matched collections of ripe and green fruits at 2 separate locations (1960 m and 1974 m) in Burguret Forest on the western side of Mount Kenya (Table 2).

Specimens of each plant from which fruits were collected were pressed in the field. Additionally, photographs were taken of representative fruits from all samples. Plant specimens and, sometimes, fruit photographs were used for identification at the East African Herbarium. For the occasional cases when fallen fruits were sampled under trees from which it was impossible to collect a specimen, plant identification was made with reference to published (Beentje, 1994; Agnew & Agnew, 1994) and unpublished lists of local flora, using fruit, bark, and leaf characters, the latter observed with binoculars.

We are grateful to the curators of the following institutions for providing tephritid specimens to IMW and RSC: BMNH = The Natural History Museum, London, UK (J.E. Chainey); MSNM = Museo Civico di Storia Naturale, Milan, Italy (F. Rigato); MRAC = Koninklijk Museum voor Midden Afrika, Tervuren, Belgium (M. De Meyer & E. De Coninck); NMKE = National Museums of Kenya, Nairobi, Kenya (W. Kinuthia); USNM = National Museum of Natural History, Washington D. C., USA (A. Norrbom); SANC = National Collection of Insects, Plant Protection Research Institute, Pretoria, South Africa (M.W. Mansell).

Results

Distribution of Oleaceous Fruit Samples

Species of Oleaceae were collected throughout the forested and woodland areas of southern Kenya. A summary of the 53 fruit samples collected from these plants is given in Table 1. The distributions of collections of Oleeae: Oleinae (four *Olea* species and *Chionanthus niloticus* (Oliv.) Stearn) are shown in Fig. 2. *Olea woodiana* Knobl. ssp. *disjuncta* P. S. Green is a coastal lowland forest species (Beentje, 1994; as *Olea woodiana* Knobl.) and was collected at 2 sites on the Kenyan south coast. The remaining four species were collected in high altitude forest in central and western Kenya. Ripe fruits of *O. europaea* ssp. *cuspidata* were sampled at an altitude of 2979 m on Mt. Elgon, western Kenya, ca. 600 m higher than that previously recorded for herbarium specimens of this species (Beentje, 1994). *Olea europaea* ssp. *cuspidata* was also found in mid-altitude woodland (Kibwesi Forest, Eastern Province Kenya, 1015 m, Fig. 1) growing on volcanic soil. However, we did not find ripe fruits at this site. Species of *Jasminum* were collected at various coastal and upland sites, while *Schrebera alata* was found only at 2 sites in highland forest in central Kenya (Fig. 3).

Insects Associated with Oleaceae

Tephritidae and their parasitoids

Tephritidae and their parasitoids were reared from fruits of Oleeae: Oleinae, represented by *Chionanthus niloticus* and 3 of the *Olea* species (Tables 2 and 3). Neither fruit flies nor their parasitoids were recovered from Oleeae: Schreberinae (*Schrebera alata)* or Jasmineae (*Jasminum* species), although fruits of these species were attacked by lepidopteran larvae (see next section). Similarly, tephritids were not recovered from the single collection we made of *O. capensis* ssp. *macrocarpa*.

Table 2. Distribution and fruit infestation indices of tephritid-positive Oleaceae species.[1]

Plant species[2]	Region[3]	Location	Altitude (m)	Sampling date	No. of fruits	Weight (gms)	*B. biguttula* per 1000 fruit (per kg)	*B. oleae* per 1000 fruit (per kg)	*B. munroi* per 1000 fruit (per kg)	*M. whartoni* per 1000 fruit (per kg)
Chionanthus niloticus	we	Koru; Brooks' farm	1565	6/4/00	1035	905	0 (0)	0 (0)	0 (0)	47 (54)
			1565	7/15/00	515	210	0 (0)	0 (0)	0 (0)	161 (395)
			1565	8/17/00	408	210	0 (0)	0 (0)	0 (0)	429 (833)
Olea europaea ssp *cuspidata*	ce	Ololua Forest	1706	2/3/00	539	110	0 (0)	18 (91)	0 (0)	0 (0)
			1823	2/23/00	nd[4]	nd[4]	0 (0)	nd[4]	0 (0)	0 (0)
			1750	2/23/00	nd[4]	nd[4]	0 (0)	nd[4]	0 (0)	0 (0)
			1823	3/26/00	775	169	0 (0)	330 (1515)	0 (0)	0 (0)
			1823	4/8/00	191	40	0 (0)	84 (400)	0 (0)	0 (0)
			1823	4/8/00	363	76	0 (0)	157 (750)	0 (0)	0 (0)
			1823	4/21/00	203	42	0 (0)	108 (524)	0 (0)	0 (0)
			1823	4/28/00	nd[4]	nd[4]	0 (0)	nd[4]	0 (0)	0 (0)
	ce	Burguret Forest	1961	5/17/02	661	134	0 (0)	0 (0)	0 (0)	0 (0)
			1974	8/15/02	2942	691	0 (0)	85 (360)	0 (0)	0 (0)
			1960	8/16/02	2235	535	0 (0)	174 (725)	0 (0)	0 (0)
			2062	9/21/02	5000	1106	0 (0)	75 (338)	0 (0)	0 (0)
			2010	11/13/02	1000	220	0 (0)	4 (18)	6 (27)	0 (0)
	we	Mau Forest	2187	9/19/00	235	47	0 (0)	17 (85)	0 (0)	0 (0)
			2175	2/3/03	80	12	0 (0)	475 (2833)	50 (333)	0 (0)
	we	Mount Elgon	2801	1/31/03	2389	1631	0 (0)	94 (138)	0 (0)	0 (0)
			2979	1/31/03	437	204	0 (0)	0 (0)	0 (0)	0 (0)
			2809	2/21/03	2000	1145	0 (0)	111 (194)	0 (0)	0 (0)

Table 2 (continued).

Plant species[2]	**Region**[3]	**Location**	**Altitude (m)**	**Sampling date**	**No. of fruits**	**Weight (gms)**	***B. biguttula*** **per 1000 fruit (per kg)**	***B. oleae*** **per 1000 fruit (per kg)**	***B. munroi*** **per 1000 fruit (per kg)**	***M. whartoni*** **per 1000 fruit (per kg)**
Olea europaea ssp *cuspidata*, green fruits	ce	Burguret Forest	1974	8/15/02	310	57	0 (0)	3 (18)	0 (0)	0 (0)
			1960	8/16/02	695	117	0 (0)	16 (94)	0 (0)	0 (0)
			2062	1/15/03	8570	940	0 (0)	1 (9)	0 (0)	0 (0)
Olea welwitschii	we	Kakamega Forest	1550	8/14/00	4219	1583	0 (0)	0 (0)	<1 (1)	0 (0)
			1550	8/15/00	267	145	0 (0)	0 (0)	4 (7)	0 (0)
			1550	9/12/00	445	184	0 (0)	0 (0)	7 (16)	0 (0)
			1630	9/19/00	98	40	0 (0)	0 (0)	0 (0)	0 (0)
			1550	9/20/00	1523	624	0 (0)	0 (0)	0 (0)	0 (0)
	we	Mau Forest	2332	8/2/01	28	35	0 (0)	0 (0)	0 (0)	0 (0)
Olea welwitschii, green fruits	we	Kakamega Forest	1550	6/2/00	638	206	0 (0)	0 (0)	0 (0)	0 (0)
	ce	Mount Kenya Forest	2448	4/9/02	69	104	0 (0)	0 (0)	0 (0)	0 (0)
Olea woodiana ssp *disjuncta*	co	Kaya Kinondo	5	7/20/00	161	38	0 (0)	0 (0)	0 (0)	0 (0)
	co	Shimba Hills	201	8/26/00	597	387	8 (13)	0 (0)	0 (0)	0 (0)

1. One *C. capitata* was reared from *O. europaea* ssp. *cuspidata* (2/23/2000) and 5 were reared from *O. woodiana* ssp. *disjuncta* (8/26/2000).

2. Ripe fruits sampled in all collections, except where indicated, when mature-sized, unripe green fruits were sampled.

3. ce = central highland forest, co = coastal lowland forest, we = western highland forest.

4. nd = tephritid positive sample, fruits neither counted nor weighed.

Table 3. Opiine parasitoids reared from tephritid-infested Oleaceae.

Plant species[1]	Reg[2]	Location	Altitude (m)	Sampling date	No. fruits	Weight (gm)	no. of tephritids reared	Tephritid species	% of tephritids parasitized	Opiine wasps reared
Chionanthus niloticus	we	Koru; Brooks' farm	1565	6/4/00	1035	905	49	*M. whartoni*	2.0	*Psyttalia* sp., 1f
			1565	7/15/00	515	210	83	*M. whartoni*	0.0	
			1565	8/17/00	408	210	175	*M. whartoni*	4.9	*Psyttalia* sp., 7f, 2m
Olea europaea ssp. *cuspidata*	ce	Ololua Forest	1706	2/3/00	539	110	10	*B. oleae*	9.1	*Psyttalia* sp., 1m
			1823	2/23/00	nd[3]	nd[3]	4	*B. oleae*	0.0	
			1750	2/23/00	nd[3]	nd[3]	3	2 *B. oleae*, 1 *C. capitata*	0.0	
			1823	3/26/00	775	169	256	*B. oleae*	1.9	*Psyttalia* sp. cf *concolor,* 1f, 1m
Utetes africanus, 1f, 1m *Psyttalia lounsburyi*, 1f										
			1823	4/8/00	191	40	16	*B. oleae*	11.1	*Psyttalia concolor*, 1f
Utetes sp[4], 1?										
			1823	4/8/00	363	76	57	*B. oleae*	8.1	*Psyttalia concolor*, 1f, 4m
			1823	4/21/00	203	42	22	*B. oleae*	4.3	*Psyttalia lounsburyi*, 1m
			1823	4/28/00	nd[3]	nd[3]	3	*B. oleae*	25.0	*Psyttalia concolor*, 1f
	ce	Burguret Forest	1961	5/17/02	661	134	0			
			1974	8/15/02	2942	691	249	*B. oleae*	30.8	*Psyttalia lounsburyi*, 45f, 54m *Utetes africanus*, 8f, 4m
			1960	8/16/02	2235	535	388	*B. oleae*	19.8	*Psyttalia lounsburyi*, 34f,55m *Utetes africanus*, 5f, 2m
			2062	9/21/02	5000	1106	374	*B. oleae*	18.1	*Psyttalia lounsburyi*, 58f,24m *Utetes africanus*, 1f
			2010	11/13/02	1000	220	10	4 *B. oleae*, 6 *B. munroi*		

Table 3 (continued).

Plant species[1]	Reg[2]	Location	Altitude (m)	Sampling date	No. fruits	Weight (gm)	no. of tephritids reared	Tephritid species	% of tephritids parasitized	Opiine wasps reared
Utetes sp[4], 1?	we	Mau Forest	2187	9/19/00	235	47	4	*B. oleae*	20.0	*Psyttalia lounsburyi*, 1f
			2175	2/3/03	80	12	38	34 *B. oleae*, 4 *B. munroi*		
	we	Mt. Elgon	2809	1/31/03	2389	1631	225	*B. oleae*	0.4	*Psyttalia lounsburyi*, 1m
			2979	1/31/03	437	204	0			
			2809	2/21/03	2000	1145	222	*B. oleae*	0.9	*Psyttalia lounsburyi*, 2m
Olea europaea ssp. *cuspidata*, green fruits	ce	Burguret Forest	1974	8/15/02	310	57	1	*B. oleae*	0.0	
			1960	8/16/02	695	117	11	*B. oleae*	38.9	*Psyttalia lounsburyi*, 4f, 1m *Utetes africanus*, 1f, 1m
			2062	1/15/03	8570	940	8	*B. oleae*	50.0	*Psyttalia lounsburyi*, 3f,2m *Utetes africanus*, 2f, 1m
Olea welwitschii	we	Kakamega Forest	1550	8/14/00	4219	1583	1	*B. munroi*	0.0	
			1630	8/15/00	267	145	1	*B. munroi*	0.0	
			1550	9/12/00	445	184	3	*B. munroi*	0.0	
			1630	9/19/00	98	40	0			
			1550	9/20/00	1523	624	0			
	we	Mau Forest	2322	8/2/01	28	35	0			
Olea welwitschii, green fruits	we	Kakamega Forest	1550	6/2/00	638	206	0		0.0	
	ce	Mt. Kenya Forest	2448	4/9/02	69	104	0			
Olea woodiana ssp. *disjuncta*	co	Kaya Kinondo	5	7/20/00	161	38	0			
	co	Shimba Hills	201	8/26/00	597	387	10	5 *B. biguttula*, 5 *C. capitata*	0.0	

1. Ripe fruits sampled in all collections, except where indicated, when mature-sized, unripe green fruits were sampled.
2. ce = central highland forest, co = coastal lowland forest, we = western highland forest.
3. nd = tephritid-positive sample, fruits neither counted nor weighed.
4. Abdomen lost, probably *U. africanus*.

Table 4. Lepidoptera and non-opiine parasitoids reared from oleaceous fruits.

Plant species	% collns producing moths (total collns)	Species of moths reared	Total no. moths	Moths per kg^{1}	Non-opiine Hymenoptera (excluding Chalcidoidea)	No. of wasps reared	Percent parasitization of moths
Chionanthus niloticus	67 (3)	Noctuidae: *Nola melanoscelis*	9	6.8	Braconidae: Braconinae sp. # 22	2	15.3
					Ichneumonidae: Cremastinae: *Pristomerus* sp	1	7.7
					Ichneumonidae: Banchinae	1	7.7
Jasminum dichotomum	0 (3)	none	0	0	Braconidae: Braconinae	1	100
Jasminum fluminense	40 (5)	Crambidae: Spilomelinae: *Palpita unionalis* Hübner	1	4.2		0	0
		Crambidae: Cybalomiinae: . *Hendecasis* sp. nr *duplifascialis* Hampson	3	12.6		0	0
		Microlepidoptera	1	4.2		0	0
Jasminum meyeri-johannis	67 (3)	Crambidae: Cybalomiinae: *Hendecasis duplifascialis*	1	1.6		0	0
		Microlepidoptera	3	4.8		0	0
Jasminum sp	33 (3)	Crambidae: Cybalomiinae: *Hendecasis duplifascialis*	1	5		0	0

Table 4 (continued).

Plant species	% collns producing moths (total collns)	Species of moths reared	Total no. moths	Moths per kg[1]	Non-opiine Hymenoptera (excluding Chalcidoidea)	No. of wasps reared	Percent parasitization of moths
Jasminum stenolobum	0 (3)	none	0	0	Braconidae: Cheloninae: Phanerotomini: *Phanerotoma* sp	.1	100
Olea capensis ssp *macrocarpa*	0 (1)	none	0	0			
Olea europaea ssp *cuspidata*	19 (21)	Tortricidae	1	<1		?[2]	?
		Microlepidoptera	7	<1			
		Carposinidae	2	<1			
Olea welwitschii	38 (8)	Crambidae: Spilomelinae: *Dolicharthria lanceolalis*	1	0.3	Ichneumonidae: Cremastinae: *Pristomerus* sp.	2	22.2
		Microlepidoptera	6	2.1			
Olea woodiana ssp *disjuncta*	50 (2)	Microlepidoptera	1	2.3	Ichneumonidae: Cremastinae: *Pristomerus* sp.	1	50
Schrebera alata	50 (2)	Microlepidoptera	2	6.3			0

1. See Table 1 for total collection weight of each fruit species; includes moth-negative and -positive samples.
2. *Bracon* sp. were reared from fruits but because tephritids were present, cannot be confidently associated with a moth host

Munromyia whartoni Copeland, **sp. nov**., a new species of the previously monotypic adramine genus *Munromyia* Bezzi, was reared from *Chionanthus niloticus* fruits collected in gallery forest in western Kenya (Table 2). A description of this species and a key to the *Munromyia* are provided below. The fruiting season of *C. niloticus* was sharply defined, beginning at the end of the "long" rainy season and lasting 3 months. *Munromyia whartoni* was reared from each of three monthly collections of fruit made over this period. Population density of *M. whartoni*, as measured by the infestation index, increased steadily over the fruiting period in 2000, after which fruits were not found (Table 2). Fruiting of its host, *C. niloticus*, was not seen during repeated visits to the same site in 2001 and 2002.

Four tephritids were reared from *Olea*: the medfly, *Ceratitis capitata* (Wiedemann), and 3 species of *Bactrocera* Macquart. The medfly was recovered, infrequently and in small numbers, from collections of *O. woodiana* ssp. *disjuncta* at the coast and *O. europaea* ssp. *cuspidata* in the central highlands as previously reported (Copeland *et al*., 2002). *Bactrocera oleae* was reared exclusively from *O. europaea* ssp. *cuspidata* in highland forests both east (1706–2062 m) and west (2175–2809 m) of the Gregory Rift Valley. *Bactrocera biguttula* (Bezzi) was found only in fruits of *O. woodiana* ssp. *disjuncta*, in lowland forest (201 m) near the Kenyan coast. A previously unknown species of *Bactrocera, Bactrocera munroi* White, **sp. nov**., was reared in relatively small numbers from both *O. europaea* ssp. *cuspidata* (central and western highland collections, 1970–2175 m) and from *Olea welwitschii* (Knobl.) Gilg & Schellenb. from Kakamega Forest (1550 m), the easternmost extension of Guineo-Congolian equatorial forest. Descriptions of the new species and a key to the African subgenera of *Bactrocera* are found below.

The olive fly was reared from 16 of 18 collections of ripe fruits of *O. europaea* ssp. *cuspidata*, and from all 3 collections of green fruits. From matched collections of ripe and green fruits at 2 separate locations in Burguret Forest, ripe fruits produced significantly more *B. oleae* per fruit than did green fruits (site 1 [1974 m], $X^2 = 25.06$, d.f. = 1, p = <0.0001; site 2 [1960 m], $X^2 = 110.85$, d.f. = 1, p = <0.0001). Two collections of ripe fruits of *O. europaea* ssp. *cuspidata*, made on Mt. Elgon at 2801 and 2809 m, represented the highest altitude at which *B. oleae* was reared from olives (Table 2). The only sample of olives taken at a higher elevation (2979 m, also on Mt. Elgon) failed to produce *B. oleae*.

Tephritid parasitoids were reared from *M. whartoni* and *B. oleae* (Table 3). A single, potentially undescribed species of *Psyttalia* Walker (Hymenoptera, Braconidae, Opiinae) was reared from 2 of 3 fruit samples that produced *M. whartoni*. Parasitization rates were relatively low, approaching 5% during the final month's collection. Three species of Opiinae were recovered from *B. oleae*: *Psyttalia lounsburyi* (Silvestri), *P. concolor*, and *Utetes africanus* (Szépligeti). A few individuals of *Bracon celer* (Szépligeti), of the braconid subfamily Braconinae, were also reared. In our collections, *P. lounsburyi* was both more common and widespread than *U. africanus* and *P. concolor*. The latter was found only in collections from Ololua Forest in Central Kenya. No wasps were recovered from samples of fruits that produced *B. munroi*, *B. biguttula*, or *C. capitata*, however few individuals of these latter 3 species were reared.

Lepidoptera and their parasitoids

Moths were reared from all four genera of Oleaceae, and were the only frugivores that attacked *Schrebera* and *Jasminum* species (Table 4). *Jasminum* fruits were preyed upon by 3 species of Crambidae, representing 2 crambid subfamilies. A *Hendecasis* sp. nr. *duplifascialis* Hampson was the only species that attacked more than one host.

Species richness of frugivorous moths was highest in *O. europaea* ssp. *cuspidata*, from which a tortricid, a carposinid, and an unplaced microlepidopteran were reared. Single moth species were reared from *S. alata*, *O. welwitschii*, and *C. niloticus*.

Relatively few parasitoids of Lepidoptera were found in our samples. These comprised two genera each of Ichneumonidae and Braconidae (Table 4).

Chalcidoidea

Most of the chalcidoid wasps we reared represent genera that contain both phytophagous species as well as parasitoids. Since our rearing protocol did not allow us to determine the trophic status of chalcidoid species, we consider them here as one group. Chalcidoids were reared from 33% (n = 21) of *O. europaea* ssp. *cuspidata* collections. Most of these were Eurytomidae, including undetermined species of both *Eurytoma* Illiger and *Sycophila* Walker. Also reared were a pteromaline Pteromalidae, a tetrastichine Eulophidae, and undetermined species of *Pseudotorymus* Masi (Torymidae) and *Eupelmus* Dalman (Eupelmidae). The only other fruit species from which chalcidoids were reared was *O. welwitschii* from which 2 undetermined species, one a eulophid and the other a eupelmid, were reared.

Taxonomy of the genus *Munromyia* Bezzi

Munromyia is placed in the subfamily Trypetinae, tribe Adramini. The limits of the Adramini (Trypetinae) have been difficult to define, leading to widely different interpretations of which genera belong in it [e.g., Hancock (1986), 3 genera including *Munromyia*; Hardy (1986), 20 genera]. Recent studies have greatly increased the number of adramine genera, largely because of the absorption into it of most of the genera previously assigned to the Euphrantini (Norrbom *et al.*, 1999a; Korneyev, 1999). Currently, 181 species in 26 genera are recognized. Primarily composed of Australasian and Oriental species, the tribe is represented in the Afrotropical region by 32 species in 8 genera (Norrbom *et al.*, 1999a,b).

Bezzi (1922) described *Munromyia* from specimens of *Munromyia nudiseta* Bezzi reared by Munro (1924) from fruits of *Chionanthus foveolatus* (E. Mey.) Stearn (as *Olea foveolata* E. Mey.). Bezzi (1922) recognized the similarity of the new genus to both *Meracanthomyia* Hendel and to *Adrama determinata* (Walk.) and, accordingly, erected the monospecific genus *Munromyia* and placed it in the Adramini (as Adraminae), where it still resides.

Key to species of *Munromyia* Bezzi

1. Median stripe of scutum black, narrow, separated from whitish dorsocentral lines by a distance about equal to width of median stripe (Fig. 4a), solid, not bisected. Scutellum uniform in color, reddish orange (Fig. 4a). Abdominal syntergite 1+2 entirely black (Figs. 4a & 4c). Anepisternum uniform in color, reddish-orange (Fig. 4c). Basal margin of apical wing spot forming an acute angle with costa, spot dark, mostly gray-brown (Fig. 5a). Aculeus ca. 8.3 × as long as wide (width measured at apex of 8th sternite [Fig. 5d]). Distiphallus with 2 rows of strongly curved, boomerang-shaped cuticular processes with finely tapered, untoothed tips (Fig. 6a) ………………………….............…..….. ***Munromyia whartoni*** Copeland, **sp. nov**.

–. Median stripe of scutum black or blackish-red, wide, filling nearly entire area between whitish dorsocentral lines, median stripe bisected by thin black line bordered by equally thin whitish lines (Fig. 4b). Scutellum bicolored, base and disk very dark red-brown, apex yellow-white (Fig. 4b). Abdominal syntergite 1+2 orange medially with anterior, lateral, and posterior margins black (Figs. 4b, 4d). Anepisternum tricolored with black band separating anterior reddish-orange area from posterior yellow-white area (Fig. 4d). Basal margin of apical wing spot forming an obtuse angle with costa, spot light brown (Fig. 5b). Aculeus c. 13.2 × as long as wide (width measured at apex of 8th sternite [Fig. 5e). Distiphallus with two rows of weakly curved cuticular processes, one row with most processes having at least 1 tooth (Fig. 6b), the other row with all or most processes lacking teeth ……................................ ***Munromyia nudiseta*** Bezzi

Munromyia whartoni Copeland, sp. nov.

Material examined. – Holotype – male (NMKE), KENYA: Nyanza Province, Koru / Brooks' Farm, 0°07.70' S, 35°16.69' E, 15.vii.2000, ex fruit *Chionanthus niloticus*, ICIPE/USAID collection 757, leg. R.S. Copeland, MNSP5, USNM ENT 00214327. Paratypes - 37 males (2 dissected), 45 females (2 dissected), Nyanza Province, Koru / Brooks' Farm, 0°07.70' S, 35°16.69' E, 15.vii.2000, ex fruit *Chionanthus niloticus*, ICIPE/USAID collection 757, leg. R.S. Copeland; 30 males, 19 females, same data except ICIPE/USAID collection 707, 4.vi.2000; 80 males, 95 females, same data except ICIPE/USAID collection 810, 17.viii.2000.

Paratypes to be distributed between NMKE, BMNH, MRAC, USNM, SANC, Texas A&M University, USA, Tel Aviv University, Israel, and the International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya.

Description. – Male (habitus, Fig. 8a). Body length 6.4–7.4 mm. Head – Scape and pedicel orange. First flagellomere black, except for short yellowish portion basad to arista; 10.4 × as long as wide, and 3 × combined length of scape and pedicel. Arista dark, except light basally; about equal in length to first flagellomere. Face orange, except for two large subantennal black spots. Frons orange, except for black ocellar triangle; three, occasionally two, pairs of frontal setae, dorsal pair 2 × as far from middle pair as ventral pair. Ocellar seta shorter than length of ocellar triangle. Orbital setae absent. Occiput orange, except for dark brown-black area behind middle of eye.

Thorax (Figs. 4a, 4c) - Length 2.6–2.9 mm. Ground color orange. Black medial stripe extending from posterior margin of scutum, nearly reaching anterior margin. A single pair of thinner, less distinct whitish dorsocentral stripes lateral to and parallel with black stripe, and separated from it by distance approximately equal to width of black stripe. Lateral scapular seta present, medial scapular absent. Anterior and posterior notopleural setae present. Presutural supra-alar seta absent. One pair each of postsutural supra-alar, postalar, and intra-alar setae. Intrapostalar seta absent. Anepisternum uniformly orange, one anepisternal seta. Katepisternum black, katepisternal seta absent. Anepimeral seta present. Scutellum uniformly orange. Basal and apical scutellar setae present.

Wing (Fig. 5a) – Length 5.1–5.8 mm, hyaline, with hemi-elliptic dark gray-brown apical spot covering about 1/3 of wing. Basal margin of spot forming slightly acute angle with costa. Spot covering, on average, 0.27 (0.25–0.30) combined length of veins Rs + R_{2+3}, 0.52 (0.49–0.54) length of R_{4+5}, and 0.74 (0.71–0.76) length of M. Pterostigma gray-brown, with narrow, irregularly-shaped, gray-brown band extending from its base to near intersection of bm-cu and CuA_1. Halter yellow.

Legs (Fig. 4c) - Yellow to yellow-orange. Fore femur with subapical brownish-black spots, covering apical 1/3 of anterior and posterior surfaces. Mid femur brown-black over apical 2/3. Hind femur brown-black over apical ?. Fore, mid, and hind tibiae brown to brown-black. Hind coxa brown-black. Fore femur with single row of ventral spines on apical 1/2. Mid and hind femora with two parallel rows of ventral spines on apical 1/2–2/3 and apical 1/2, respectively.

Abdomen (Figs. 4a, 4c) - Syntergite 1+2 black, tergites 3–4 orange or dark orange, tergite 5 orange.

Terminalia (Fig. 7) - Epandrium nearly spherical, lateral surstylus elongate, in lateral view tapering to blunt point, prensisetae globular. Distiphallus with 2 rows of boomerang-shaped cuticular processes, each tapered at apex to a fine point. Glans elongate, columnar.

Description. - Female. Similar to male, except tergites 3–6 and oviscape usually orange, sometimes dark orange. Body length 8.1–8.8 mm. Thorax length 2.8–3.0 mm. Wing length 5.7–6.0mm. Eversible membrane with 2 ventral and 3 dorsal taeniae. Ventral pair solidly sclerotized on basal 1/5–1/4 of eversible membrane, becoming rows of teeth increasing gradually in size until reaching ca. middle of eversible membrane, whereupon they diminish in size, becoming minute and covering rest of ventral surface including space between taeniae. Dorsal taeniae solidly sclerotized on basal 1/8–1/10 of eversible membrane, becoming rows of teeth increasing in size and then diminishing as for ventral taeniae, except dorsal taeniae also with ca. 8–12 prouncedly larger clamshell-shaped teeth (Fig. 5c) spread along this length. Size of clamshell-shaped teeth greater in middle taenia. Spaces between lateral and middle taeniae without any teeth on ca. basal 1/5 of eversible membrane. Aculeus tapered, then slightly broadened at base of tip, ca. 1.2 mm long (Fig. 5d), ca. 8.3 × as long as wide (measured at apex of 8th sternite); tip broadly triangular, evenly tapered. Three spermathecae, more or less elongate and vase shaped, swollen apically, base slightly flared with serrate projections surrounding spermathecal duct. Surface densely covered with slender, acute denticles.

Host: - *Chionanthus niloticus* is the only known host of *M. whartoni*.

Remarks: - *Munromyia whartoni* is known only from a single gallery forest surrounded by subsistence farms and commercial sugar cane plantations in western Kenya. This species is most closely related to *M. nudiseta*, based on similarities in both physical and behavioral characteristics (see discussion). Nonetheless, it is readily distinguished from its congener by the coloration of the anepisternum and scutellum, by the relative width of the medial vitta of the scutum, and by the shape of the apical wing spot. Characters of both male and female genitalia are also useful in separating the species and show that they are not simply color morphs of the same species.

Etymology: - This species is named in honor of Bob Wharton whose scholarship and enthusiasm for field biology are an inspiration.

Taxonomy of *Bactrocera* subgenus *Daculus* Speiser

There are approximately 500 described species of *Bactrocera*, only 10 of which are native to Africa [see Norrbom *et al.* (1999b) for details of nomenclature and synonomy], the remainder being found in the Asian, Australasian and Pacific regions. In addition, 2 species of Asian origin are now established in Africa: *B.* (*B.*) *zonata* (Saunders) (in Egypt, Mauritius and Reunion) and *B.* (*Zeugodacus*) *cucurbitae* (Coquillett) (in East Africa, Mauritius, Reunion and West Africa). Conversely, 1 native African species, the olive fly, *B.* (*Daculus*) *oleae* (Rossi), is widespread in the Mediterranean area and has recently become established in California. A second African species of *Bactrocera* associated with *Olea europaea* is described here, together with a brief review of related African *Bactrocera* spp.

Most of the native African *Bactrocera* spp. have been placed in the subgenera *Afrodacus* Bezzi, *Daculus* Speiser and *Gymnodacus* Munro, all of which have African type species (*Chaetodacus biguttulus* Bezzi, *Musca oleae* Rossi and *Dacus mesomelas* Bezzi, respectively). The only exception is *B.* (*B.*) *nesiotes* Munro, whose true position cannot be ascertained as no male has been collected. These subgenera are characterized by differences in secondary sexual characters and chaetotaxy (see key for details), although the latter has been shown to be a poor basis for subgeneric classification (White, 1999).

Most taxonomic studies of *Bactrocera* spp. have been of a regional nature but the world species of *Afrodacus* and *Gymnodacus* were reviewed by Hardy (1955, 1954, respectively), who included some non-African species in those subgenera, as have subsequent authors. However, White & Evenhuis (1999) suggested that Asian species assigned to the subgenus *Gymnodacus* might be more closely allied to *Bulladacus* Drew & Hancock, than to true African *Gymnodacus*. Similarly, non-African species hitherto assigned to the subgenus *Afrodacus* should be regarded as species of the subgenus *Bactrocera* with atypical chaetotaxy. The difference between *Afrodacus* spp. and *Daculus* is small (presence or absence of prescutellar acrostichal setae) and, since both groups include olive associated species with shared morphological features (see key), *Afrodacus* is here placed in synonymy with *Daculus*. The larvae of 3 species, *B.* (*D.*) *oleae*, *B.* (*D.*) *biguttula* (Bezzi), and *B.* (*D.*) *munroi,* or perhaps their common ancestor, adapted to the oily and presumably hostile environment of the olive fruit.

The following nomenclatural changes are made:
The subgenus *Afrodacus* Bezzi 1924: 469, type species *Chaetodacus biguttulus* Bezzi, by monotypy [published August 1924, Carroll *et al.* (1998)] is a new synonym of subgenus *Daculus* Speiser 1924: 140, type species *Musca oleae* Rossi, by original designation [published 18th July 1924, Carroll *et al.* (1998)].

The following non-African species, previously placed in the subg. *Afrodacus*, are now placed in the subg. *Bactrocera* s.str.: *B. brunnea* (Perkins & May), *B. fastigata* Tsuruta & White, *B. grandistylus* Drew & Hancock, *B. hypomelaina* Drew, *B. jarvisi* (Tryon), *B. minuta* (Drew), *B. ochracea* Drew. The African species newly transferred to the subg. *Daculus* are listed in the following key.

Annotated key to African *Bactrocera* subgenera and subgenus *Daculus* species

1. Yellow or orange mark extended across both anatergite and katatergite (covers the centers of both sclerites). [Scutum with anterior supra-alar and prescutellar acrostichal setae. Male with a pecten] .... subg. ***Bactrocera*** Macquart

–. Yellow mark, if present, confined to katatergite, or at most slightly extended onto anatergite ... 2

2. Scutum with anterior supra-alar setae. Male without a pecten (or pecten reduced to a few fine hairs). Male costa between costagial break and humeral crossvein with stout setulae (stouter than on section before costagial break) .... subg. ***Gymnodacus*** Munro

–. Scutum without anterior supra-alar setae. Male with a pecten. Male costa between costagial break and humeral crossvein without stout setulae (setae similar before and after costagial break).. (subg. ***Daculus*** Munro) ... 3

3. Wing with a narrow dark marking along crossvein r-m (sometimes indistinct). Scutellum concolorous with scutum. Scutum without lateral postsutural vittae 4

–. Wing without any markings along crossveins. Scutellum not concolourous with scutum (yellow, with either a narrow basal darker line, dark apically, or largely dark and laterally yellow). Scutum usually with lateral postsutural vittae (absent in *B. oleae*; sometimes hard to discern or faded in other species) 5

4. Face with a dark spot in antennal furrow. Notopleural callus yellow. Microtrichia throughout the narrow section of cell br. [South Africa; host unknown] ..... ***lucida*** (Munro)

–. Face without a dark spot in antennal furrow. Notopleural callus concolorous with scutum. Microtrichia confined to anterior edge of narrow section of cell br. [Kenya, South Africa; host is *Duranta erecta* L. (Verbenaceae; Munro, 1984 (as *Duranta repens*), R. Copeland, unpubl. data)] .... ***nigrivenata*** (Munro)

5. Wing with a very large apical dark marking that extends from anterior (costal) edge to at least vein M 6

–. Wing with costal band at most slightly enlarged apically 7

6. Scutum black. Scutellum markings black; either largely black, yellow laterally; or with a conspicuous black apical spot. [Mauritius and Reunion. Known host *Calophyllum tacamahaca* Wildd. (Clusiaceae; S. Quilici *pers. comm.*)].. ***montyanus*** (Munro)

-. Scutum red-brown. Scutellum yellow, except for narrow red-brown basal margin and trace of red-brown apical spot. [Madagascar; host unknown.] .... ***menanus*** (Munro)

NOTE: *Dacus andriae* Munro was recently placed in synonymy with *B. menanus* by Hancock & Drew (2001).

7. Scutum without prescutellar acrostichal setae. Scutellum with dark colored (fuscous to black) basal band or triangle; yellow laterally and apically .... ***oleae*** (Rossi)

-. Scutum with prescutellar acrostichal setae. Scutellum with a colored (red brown to black) marking from base to apex; yellow laterally 8

NOTES: *Bactrocera* (*Daculus*) *oleae* is found in eastern and southern Africa (Eritrea, Kenya, Lesotho, South Africa), and throughout the olive growing areas of the southern Palaearctic (including North Africa); it has recently become established in California, USA. In Kenya its host is *O. europaea* ssp. *cuspidata* (RSC data from Central and Western Highlands); in South Africa *O. europaea* ssp. *cuspidata* (Munro, 1924, as *O. verrucosa*) and cultivated olive, *O. europaea* ssp. *europaea* (Hancock, 1989).

8. Scutum red-brown with a pair of black or dark submedial stripes, which may be divided or partly divided at suture, and which broaden apically. Abdomen red-brown, with a pair of dark sublateral or lateral markings on tergite III and sometimes tergite IV. Face with a medium sized (0.16–0.24mm in South Africa, 0.20–0.25mm wide in Kenya) dark spot in each antennal furrow .... ***biguttula*** (Bezzi)

-. Scutum predominantly black; sometimes fuscous medially (paler if teneral). Abdomen predominantly black; usually fulvous across apex of tergite II and sometimes with paired red-brown areas sub-medially on tergite IV, and sometimes III. Face usually with small to very small dark spots (up to 0.12mm wide in Kenya, 0.16mm wide in Ruwenzori area); sometimes completely lacking .... ***munroi*** White, **sp. nov.**

NOTES: *Bactrocera* (*Daculus*) *biguttula* is known from Kenya (Coast Province), Mozambique and South Africa. In Kenya its only known host is *O. woodiana* ssp. *disjuncta* (RSC data); in South Africa it is recorded from *Olea capensis* ssp. *capensis* (Munro, 1924, as *O. laurifolia*), *O. woodiana* and *Chionanthus foveolatus* (Munro, 1924, as *O. foveolata*).

Specimens examined of *B. biguttula* – KENYA: 1 male (dissected, BMNH), 4 females (1 dissected, BMNH), Coast Province, Shimba Hills, 26.viii.2000, reared ex *O. woodiana* ssp. *disjuncta*, leg. R.S. Copeland, sample 824/K702. SOUTH AFRICA: 1 male, 2 female, paralectotypes, East London, 4–10.vii.1922, leg. H.K. Munro,

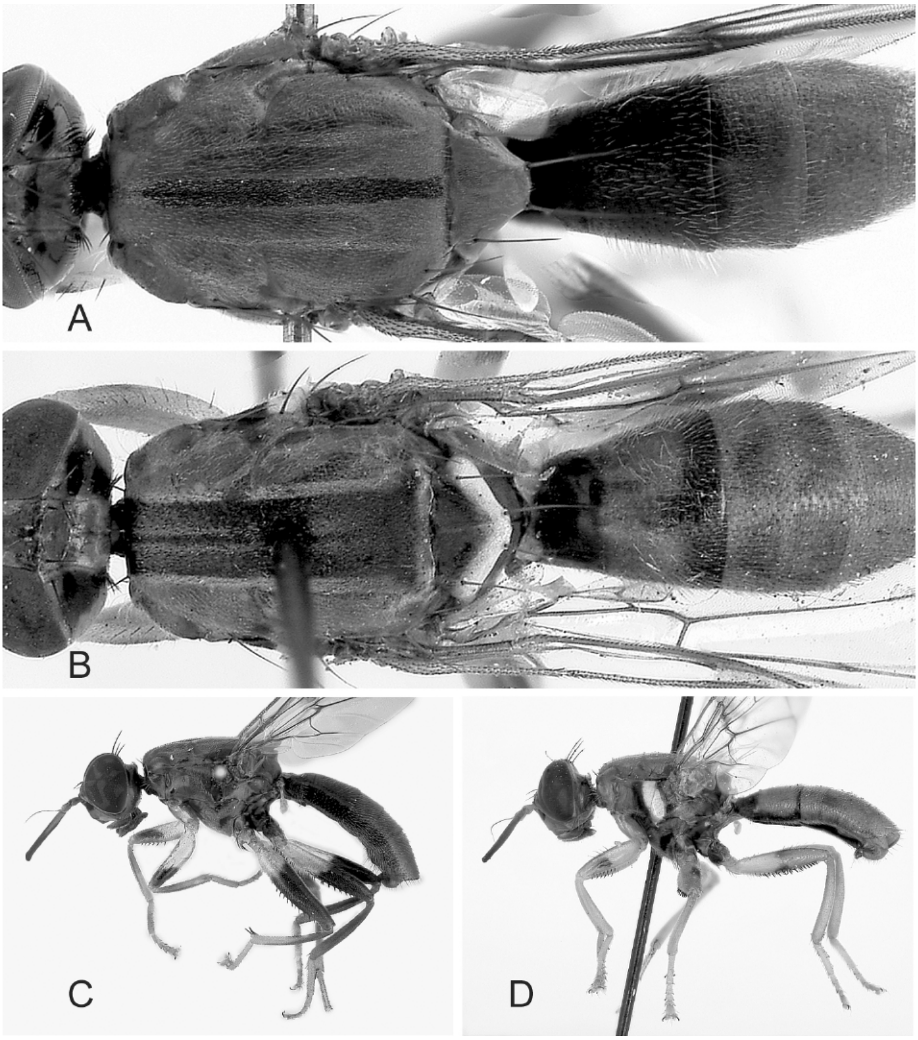

Figure 4. Habitus figures. **a**. *M. whartoni*, dorsal; **b**. *M. nudiseta*, dorsal; **c**. *M. whartoni*, lateral; **d**. *M. nudiseta*, lateral.

reared ex *O. woodiana* (MSNM); 9 males, 11 females (SANC), various localities, including specimens reared from all listed hosts (SANC). MOZAMBIQUE: 1 male, 1 female (SANC), Lourenco Marques, 10.v.1937, leg. J. Lima, not reared.

Bactrocera (Daculus) munroi White**, sp. nov.**

Dacus (Afrodacus) biguttulus: Munro 1957: 860, not Bezzi 1922: 294, misidentification.

Material examined. – Holotype male (NMKE), KENYA: Western Highlands, Rift Valley Province, Mau Forest (0°14.13' S, 35°32.94' E), 2175 m, 3.ii.2003, reared ex fruit *Olea europaea* ssp. *cuspidata*, sample A&M 2460, leg. R.S. Copeland. Paratypes - 2 males (1 dissected), 1 female, same data as holotype. KENYA: 1 male, 2 females (1 dissected), Central Highlands, Central Province, Burguret Forest (0°6.87' S, 37°3.29' E), 13.xi.2002, reared ex fruit *Olea europaea* ssp. *cuspidata*, sample A&M 2301, leg. R.S. Copeland; 1 female, Western Highlands, Western Province, Kakamega Forest (0°14.13' N, 34°51.87' E), 1550m, 14.viii.2000, reared ex fruit *Olea welwitschii*, sample A&M 821, leg. R.S. Copeland; 1 male, 2 females, same locality, 12.ix.2000, reared ex fruit *Olea welwitschii*, sample A&M 884, leg. R.S. Copeland; 1 female (dissected), same locality, 29.iii.2000, reared ex fruit *Prunus africana*, sample A&M 574, leg. R.S. Copeland; 3 males (1 dissected), 1 female, same locality (0°13.14' N, 34°54.14' E), 1630m, 13.iv.1999, reared ex fruit *Prunus africana*, sample A&M 67, leg. R.S. Copeland; Kenyan paratypes to be distributed between BMNH, MRAC, NMKE and SANC. DEMOCRATIC REPUBLIC OF CONGO: 1 female (MRAC), Kivu, Rwankivi, 3.xii.1943, leg. J.V. Leroy. UGANDA: 1 female (BMNH), Katwe, 26.xii.1934, leg. F.W. Edwards.

Description. – male. Head - Pedicel + 1st flagellomere not longer than ptilinal suture. Face usually with dark spot in each antennal furrow (sometimes absent in males, rarely absent in females; if present, usually small (about 0.10mm wide), rarely larger (0.16mm in Congo and Uganda specimens) and round. No other facial markings. Frons with 2 pairs of frontal setae; without spots at seta bases.

Thorax - Predominant color of scutum black, sometimes fuscous or narrowly dark red-brown medially. Postpronotal lobe partly pale, dark anteromedially. Notopleural lobe yellow. Notopleural suture without isolated wedge shaped mark. Scutum with lateral postsutural vitta (yellow; narrow; sometimes tapered; not extended anterior to suture; extending posteriorly almost to posterior supra-alar seta; sometimes indistinct). Scutum without medial vitta. Scutellum patterned; black or dark fuscous from base to apex, yellow laterally. Anepisternum with yellow band from notopleuron to (or almost to) katepisternum; narrow, dorsally not reaching anterior notopleural seta. Katepisternal mark about as broad as anepisternal stripe (at katepisternum-anepisternum suture). Yellow marking on hypopleural callus confined to katatergite. Notopleuron with anterior seta. Scutum without anterior supra-alar or prescutellar acrostichal seta. Scutellum without basal setae.

Wing – Length, 4.3–5.1mm. Cells bc and c with microtrichia confined to anteroapical corner. Cell br (narrowed part) with microtrichia confined to anterior half. Cell bm without microtrichia. Crossvein R-M distal to middle of cell dm. Costal band shallow (or incomplete), not extending posterior to R_{2+3}, slightly expanded apically. Wing with anal streak. Cells bc and c hyaline. No other wing patterning.

Legs – All femora, fore and mid tibiae yellow; hind tibia fulvous.

Abdomen - Predominant colour of abdomen red-brown to black. Tergites not fused. Abdomen not petiolate. Tergites III and IV entirely dark, or red-brown submedially (leaving medial dark stripe).

Terminalia and secondary sexual characters - Tergite III with pecten (setal comb) on each side. Basal costal sections without thicker setulae than other sections. Wing with deep indent in posterior margin; with microtrichia around apex of vein A_1+CuA_2. Hind tibia with preapical pad. Surstylus apex evenly rounded to point (apparently identical to that of *B. biguttula*; figured by Munro, 1984, Fig. 19).

Description. – female (habitus, Fig. 8b) – Aculeus length 1.0mm (2 measured; indistinguishable from *B. biguttula* in shape or length); apex pointed. Other characters as male except secondary sexual characters (i.e. tergite III without pecten; wing without deep indent in posterior margin; without microtrichia area around apex of vein A_1+CuA_2; hind tibia without preapical pad).

Hosts. – All of the Kenyan specimens were reared, mostly from wild olives, namely *O. europaea* ssp. *cuspidata* and *O. welwitschii.* However, this species was also reared from *Prunus africana* (Hook.f.) Kalkm. on two separate occasions, indicating that this is probably a normal host association. All 3 plant hosts are distributed in mid or high altitude, inland forests. This contrasts to the hosts of *B. biguttula* (listed above), all of which have predominantly lowland, coastal distributions both in Kenya (Beentje, 1994) and southern Africa (Cotes Palgrave, 1983). *Bactrocera biguttula* has never been recorded from *Olea europaea*, and aside from the rather odd association with *Prunus*, *B. munroi* has more in common in its host relationships with *B. oleae* than it does with *B. biguttula*. *Bactrocera munroi* and *B. oleae* were reared from the same sample of *O. europaea* ssp. *cuspidata* from Burguret Forest, Central Highlands, Kenya (R. Copeland, unpubl. data).

Remarks. – *Bactrocera munroi* is known only from highland areas close to the equator, from the Ruwenzori area of eastern Congo and Uganda, to the highland areas of Kenya west (Kakamega

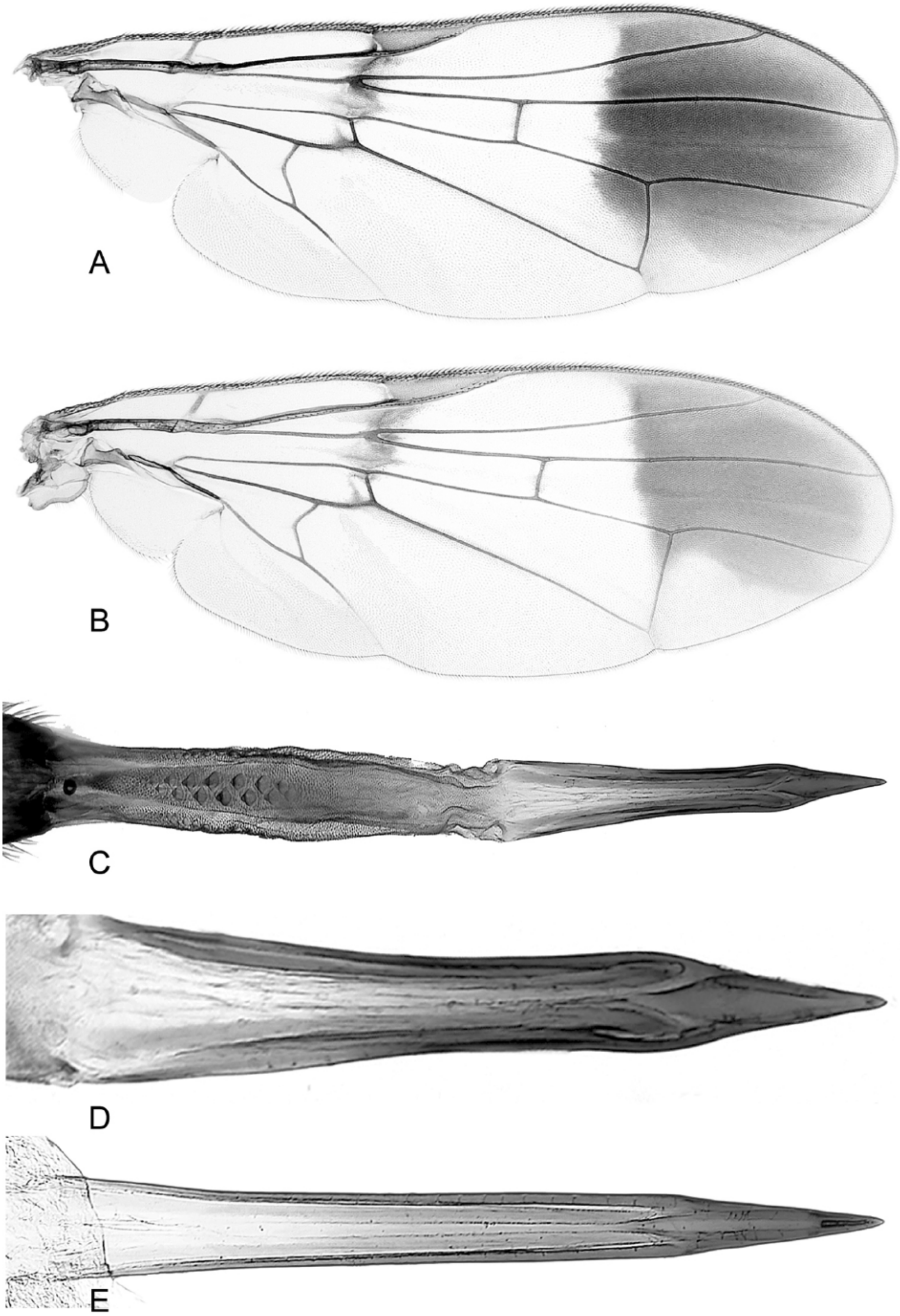

Figure 5. **a**. *M. whartoni*, wing; **b**. *M. nudiseta*, wing; **c**. *M. whartoni*, eversible membrane and aculeus; **d**. *M. whartoni*, aculeus; **e**. *M. nudiseta*, aculeus.

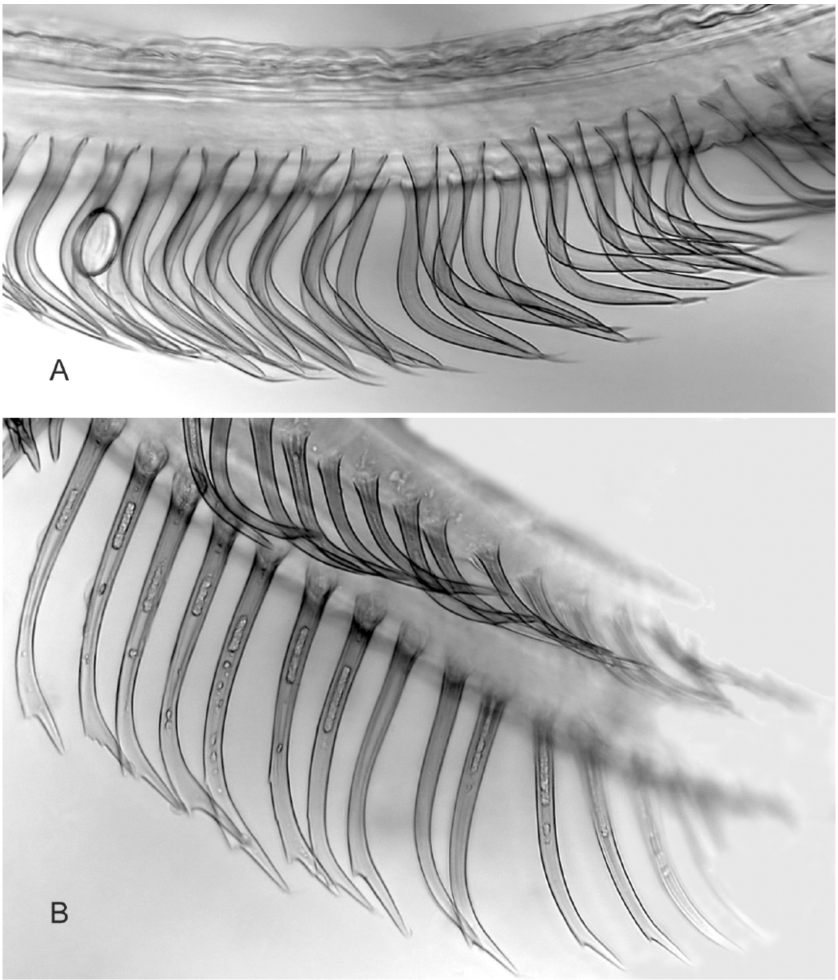

Figure 6. **a**. *M. whartoni*, cuticular processes on distiphallus, **b**. *M. nudiseta*, cuticular processes on distiphallus.

Forest and Mau Forest) and east (Burguret Forest, Mt. Kenya) of the Rift Valley. It is a much darker fly than *B. biguttula* and usually has smaller facial spots, or no facial spots at all, although no other differences have been detected (the aculeus, surstyli and glans of Kenyan specimens of both species appear to be nearly identical). The facial spots of *B. munroi* are variable. In Kenyan specimens the spots are either very small or absent whereas in the two specimens known from the Ruwenzori they are larger (0.16mm), but still smaller than most *B. biguttula* (0.16-0.25mm). Specimens from both *O. welwitschii* and *O. europaea* ssp. *cuspidata* either lack facial spots or have small facial spots (0.10-0.12mm wide); presence and absence has been observed in both sexes and from both hosts; specimens from *P. africana* all have small spots (c. 0.10mm). The Ugandan specimen is paler than the other specimens, with the scutal stripes slightly more similar to the pattern seen in typical *B. biguttula*. It also has what appears to be an irregular shaped narrow medial postsutural vitta, but it is a damaged and rather teneral specimen, and its pale scutum pattern and apparent vitta may be no more than artifact.

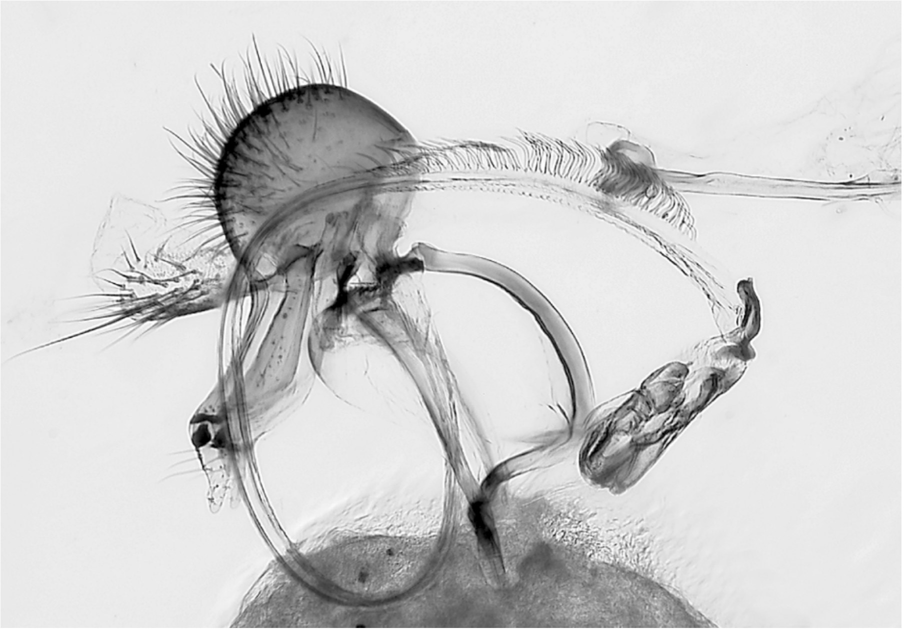

Figure 7. *M. whartoni*, male terminalia.

Etymology. – This species is named after H.K. Munro, in honour of his 60 years of research on African Tephritidae, which began in 1924 with his study of the fruit flies of wild olives.

Discussion

Munromyia whartoni is known from a single gallery forest on one farm in western Kenya. Similar small patches of forest are found throughout the agricultural areas of southern Kenya. As a whole, these forest relicts may harbor significant numbers of undescribed and threatened species. It is not known how local populations of *M. whartoni* or, for that matter, *B. oleae* survive over long periods in the apparent absence of their only known hosts, but some previous observations may be relevant. Munro (1924) was able to keep adults of *M. nudiseta* alive in the laboratory for 11 months, and adults of Mediterranean populations of *B. oleae* are known to enter a facultative reproductive diapause during hot summer months or months when fruits are absent (Fletcher, 1989). Nothing is known about the behavior or longevity of Kenyan *B. oleae* or *M. whartoni*, but it is possible that physiological adaptations play a role in maintaining populations of these species. Additionally, although fruiting of *C. niloticus* and *O. europaea* ssp. *cuspidata* (in Ololua Forest) was uniform and intense during only one year of our sampling, small numbers of fruit may appear on few trees (as they did in Ololua Forest) during "non-fruiting" years, providing enough nutritional substrate to support a breeding population of flies.

Like *M. nudistea, M. whartoni* larvae attack the seeds of *Chionanthus* fruits. Pupation took place exclusively within the fruit (R. Copeland, pers. observ.) a behavior also noted by Munro (1924). The adults of both species are apparent mimics of aculeate Hymenoptera (Fig. 8a), exhibiting rapid wasp-like movements of both the wings and the abdomen (Munro 1924; R. Copeland, pers. observ.). Both

Munromyia species also have interesting structures of the male and female genitalia. In addition to the denticles often found on the eversible membrane of tephritid females, there is a small series of larger clamshell-shaped projections. What may be homologous structures occur on the eversible membrane of *Adrama magister* Lee (Lee, 1991). In addition, males of both species possess 2 rows of pronounced cuticular processes projecting out from the surface of the distiphallus. Apparently similar structures are found on the distiphallus of some males of the otitid subfamily Otitinae (Steyskal, 1987; p. 803) and of the tephritine fruit fly *Freidbergia mirabilis* Merz (Merz, 1999; p. 657). The functions of these structures of the male and female terminalia of *Munromyia* are unknown.

Previously, *Munromyia* was known only from the type species, whose distribution is limited to Eastern Cape Province, South Africa. The discovery of a second species in western Kenya increases the range of *Munromyia* by ca. 3600 km, across 30 degrees of latitude. Two other *Chionanthus* species are found in Kenya. *Chionanthus battiscombei* (Hutch.) Stearn is widely distributed in dry forests above 850 m, and *Chionanthus mildbraedii* (Gilg. & Schellenb.) Stearn is known from wet forests above 1550 m in the western part of the country. We were unable to find fruiting specimens of either species and it would be of interest to discover whether *Munromyia* breed in seeds of their fruit.

Unlike South Africa, where *B. oleae* also breeds in introduced commercial olive (*O. europaea* ssp. *europaea*) (Hancock, 1989), in Kenya, the indigenous olive *O. europaea* ssp. *cuspidata* is the only known host. Although commercial olive was introduced into Kenya during colonial times, all established plants are presumed to have been infertile (Greathead, 1976). We were able to collect *O. europaea* ssp. *cuspidata* and its primary tephritid pest, *B. oleae*, in various habitats and over a substantial range of altitudes throughout the forested areas of southern Kenya. This olive species was found in *Croton-Brachylaena-Calodendrum* Forest (Beentje, 1990), represented in our study by Ololua Forest (Fig. 1). It was also collected on Mt. Elgon in *Juniperus-Nuxia-Podocarpus* Forest (Beentje, 1990), and in Burguret Forest on the western slope of Mt. Kenya, an example of *Juniperus-Olea* Forest (Beentje, 1990). The collections made in Mau Forest were in a highly disturbed site of what probably had been a stand of *Juniperus-Olea* Forest.

The fruiting period of *O. europaea* ssp. *cuspidata* was not always clearly defined. In Ololua Forest, olives and *B. oleae* were found in abundance during three consecutive months between the short and long rainy seasons in 2000. Like *C. niloticus* in western Kenya, *Olea* fruits were absent (except in insignificant numbers on very few trees) in Ololua Forest during 2001 and 2002. In contrast, Burguret Forest produced ripe fruits over the 7-month period in which we sampled there, and many trees had green fruits during the final sampling date (November 2002) suggesting that fruiting may be year round in this location. Although only sampled on two occasions in Mau Forest, west of the Rift Valley, fruits of *O. europaea ssp. cuspidata* were collected at markedly different times of the year (September and February) and seasonality may be absent there as well. Our observations on the lack of an annual fruiting season in at least one population of *O. europaea* ssp. *cuspidata* recall the difficulties involved in a previous collection expedition to Kenya in 1975 when, despite using herbarium records as a guide to likely fruiting periods, Greathead (1976) was unable to find any olive fruits over two months of searching. A more rigorous longitudinal study of fruiting phenology of *Olea* species is necessary to determine whether patterns, if any, in fruit production exist in the wild.

Available quantitative data on development of olive fly in wild hosts is limited and, as noted by Neuenschwander (1982), often not readily accessible (e. g., Greathead, 1976). Our samples of mature fruits of *O. europaea* ssp. *cuspidata* were almost always (88.9%) infested, despite the irregular nature of the fruiting cycle at most sites. Infestation indices (mean 613.2 adults per kg ripe fruit, range 18–2833) were generally higher than those reported by Greathead (1976) for his samples (mean 81.3, range 1–410) from the same host plant in Ethiopia. Neuenschwander (1982), working in South Africa, found that many wild olive trees suffered no apparent attack by *B. oleae* but a few trees were heavily infested. Large collections of olive fly were previously obtained from wild olives in Kenya in 1949 (Clausen *et al.*, 1965) as part of a biological control program. Reported infestation rates (approximately 77,000 puparia from 100 gallons of olives) are difficult to compare with our collections.

The collections made at over 2800 m in Mt. Elgon forest represent the highest recorded observations of both the host fruit and olive fly. Previously, herbarium records (East African Herbarium,

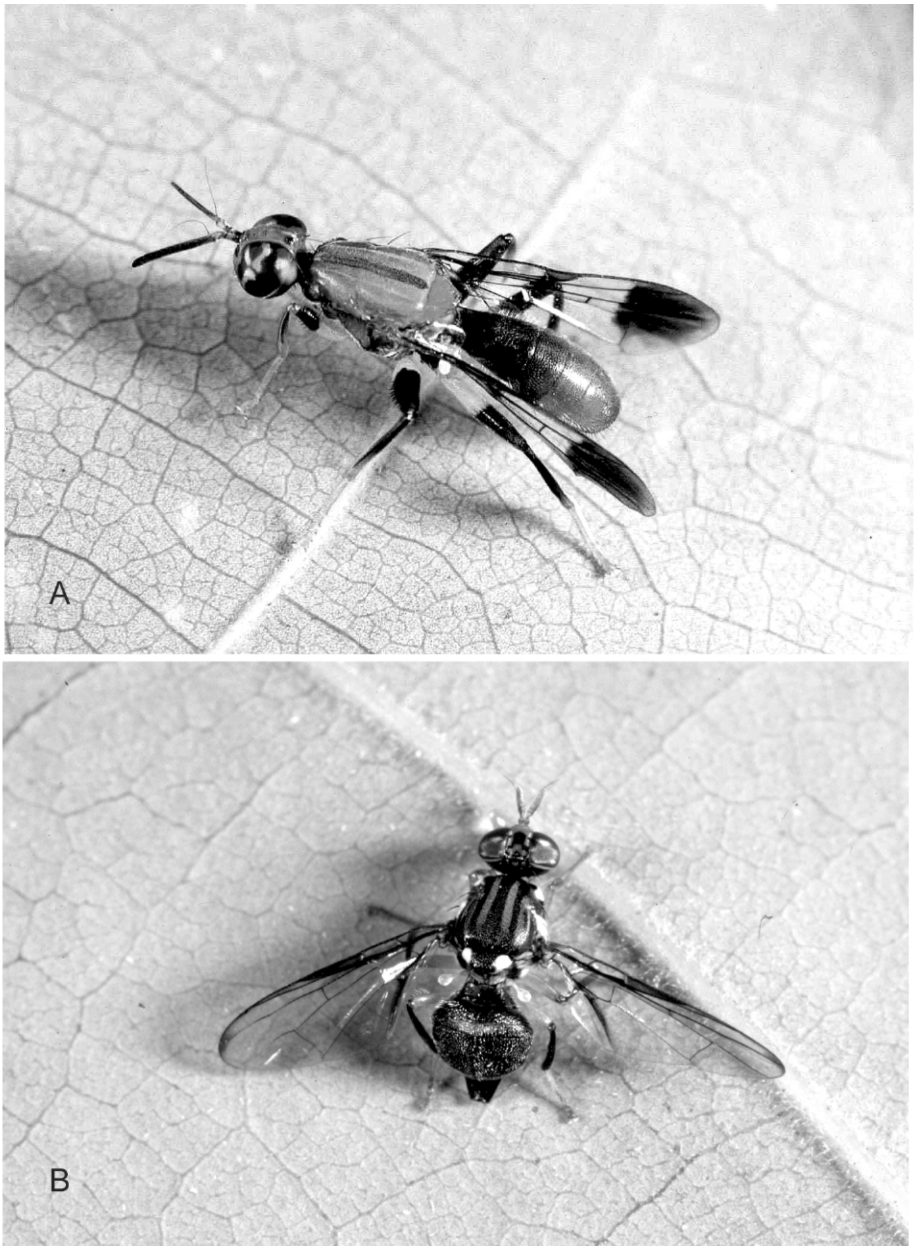

Figure. 8. **a**. *M. whartoni*, male habitus, live specimen; **b**. *B. munroi*, female habitus, live specimen.

National Museums of Kenya) indicated 2400 m as the highest collection record for *O. europaea* ssp. *cuspidata* (Beentje, 1994). Our collections on Mt. Elgon encompassed an altitudinal range of 2801–2979 m, nearly 600 m higher than the previously recorded maximum. This range may contain the absolute maximum altitude at which *B. oleae* is able to breed. Olives collected at the higher altitude failed to produce *B. oleae* while the collection made at 2801 m on the same day and another made three weeks later at 2809 m were infested (Table 2).

The discovery of *B. munroi* represents only the second *Bactrocera* species known to infest *O. europaea* s.l. Although the collections produced small numbers of *B. munroi* (Table 2), our rearing results show that it has a wider range of hosts than its congener *B. oleae*. In addition to its presence in samples from *O. europaea ssp. cuspidata* (where it co-occurred with *B. oleae*) it also developed in fruits of *O. welwitschii* and *Prunus africana*, from collections made in remnant, wet Guineo-Congolian forest in Kakamega. Production of *B. munroi* from *Prunus* was somewhat surprising, since the Rosaceae are not closely related to the Oleaceae (Soltis *et al.,* 2000). Although two different collections (13.iv.1999, 29.iii.2000) of *P. africana* produced five specimens, rearings from this fruit should be reconfirmed. Nonetheless, the wider host range of *B. munroi* and its occurrence in very different forest types suggest that its range in sub-Saharan Africa will exceed that of *B. oleae*, perhaps extending far into the equatorial rain forest belt to the west.

Is *B. munroi* a potential pest of commercial olive? Although this species clearly ranks far below *B. oleae* as a pest of wild olive in Kenya (it was present in 11.1% of the samples of ripe *O. europaea* ssp. *cuspidata*, while *B. oleae* was present in 88.9%), it is impossible to predict its potential as a pest on cultivars of *O. europaea* ssp. *europaea*. *Bactrocera oleae* itself is apparently a less important pest on cultivated olive in South Africa than in the Mediterranean Region (Neuenschwander, 1982; Hancock, 1989), perhaps because of the greater abundance of natural enemies in South Africa (Neuenschwander, 1982). Additionally, commercial olive is a far different fruit in both size and texture from wild olive (*O. europaea* ssp. *cuspidata*) and development of *B. munroi* might be more (or less) favored by a host switch of this kind.

Bactrocera biguttula was previously known only from South Africa. There it has been reared from the fruit of 3 plant species, all Oleaceae. Munro (1924) reared *B. biguttula* from *Olea woodiana* Knobl. ssp *woodiana*, *Chionanthus foveolatus*, and *Olea capensis* L. ssp. *capensis*. In Kenya, we reared *B. biguttula* from *O. woodiana* ssp. *disjuncta*, the only *Olea* or *Chionanthus* found in coastal lowland habitats. However, *C. battiscombei* is found in Coast Province, Kenya at altitudes as low as 850 m and it would be interesting to collect fruits from this population to see if *B. biguttula, Munromyia* species, or both develop in them.

Tephritidae were only reared from Oleaceae in the tribe Oleeae, subtribe Oleinae. While our sole representative of Oleeae, Schreberinae has a woody fruit and was not expected to yield fruit flies, it is noteworthy that none of the 17 collections of *Jasminum* species (tribe Jasmineae) produced Tephritidae. Although we can only speculate as to the reasons for this absence, it is probable that some feature of ripe *Jasminum* berries is not suitable for larval development of fruit flies. Fruits from all of our *Jasminum* collections were extremely aqueous and consistency of the mesocarp may be a factor. In contrast, the crambid larvae that developed in *Jasminum* possess mechanisms for exploiting this substrate.

While numerous parasitic Hymenoptera (Parasitica) were reared from olives, our rearing program was not designed to associate unequivocally with their hosts either the ectoparasitoids or those that pupated inside the fruit. They have thus been excluded from the dataset in Table 3. Species of ectoparasitoids included members of the genus *Eupelmus* (Eupelmidae) and *Bracon* (Braconidae). Both *Eupelmus* and *Bracon* contain species that are well known as parasitoids of olive fly, and Neuenschwander (1982) found *Bracon celer* (Szépligeti) to be the most abundant parasitoid of olive fly in his collections from South Africa. *Bracon celer* was reared from olives collected from Burguret Forest, where it was the third most common species of parasitoid, and was undoubtedly attacking *B. oleae*. It was rare or absent in samples from other sites. Many Eurytomidae were also reared from olive samples, but at least some of the species in this family are known to be phytophagous on olive seeds and some are also parasitoids of other chalcidoids in olive fruits.

Three species of endoparasitoids were reared from olive fly puparia, and host associations could thus be confirmed. All 3 belong to the braconid subfamily Opiinae, which are exclusively koinobiont endoparasitoids of cyclorrhaphous Diptera (Wharton, 1997, 1999). Where parasitoids were abundant, *Psyttalia lounsburyi* was the dominant species, followed by *Utetes africanus*. *Psyttalia concolor* was rarely seen in olives, though a species indistinguishable from *P. concolor* was commonly reared from the *Ceratitis capitata* in coffee in the central highlands (Wharton *et al.*, 2000). All three species have previously been reared from olive fly.

Psyttalia lounsburyi is known only from Kenya and South Africa (Silvestri, 1913; Clausen *et al.*, 1965; Neuenschwander, 1982). *Utetes africanus* is also known from these two countries, but has also been collected in Eritrea. Individuals from Eritrea are generally darker and were recognized as *U. africanus* var. *orientalis* Silvestri (1913). This dark form is the one we have reared in Kenya. Silvestri (1913) noted briefly that *U. africanus* attacks the larval stage of its host and emerges from the puparium. Additional details of the biology of these two species have yet to be published, but a culture of *P. lounsburyi* has been established in Nairobi from our samples and it also oviposits in larval stages of the host (S. Mohamed, pers. comm.). Details on its biology will be published separately.

Our samples suggest that the high elevation forests of Kenya will be good sources of natural enemies of olive fly for use in classical biological control programs. The complex of parasitoids in Kenya is sufficiently different from that found by Neuenschwander (1982) in South Africa to warrant collections from both countries. Rates of parasitization in our samples (Table 3) are consistent with the roughly 10% found by Clausen *et al.* (1965) in 1949, though there was considerable between-sample variation. Clausen *et al.* (1965) did not separate the species of opiines that they reared, so it is not possible to determine if the relative abundance of the three species we reared was the same as in their samples. Examination of voucher material in the USNM (by RAW), indicates, however, that the same species were reared.

Frugivorous Lepidoptera were more diverse in the Oleaceae than were Tephritidae, although infestation levels were much higher for the fruit flies. A similar pattern was found for insects attacking non-oleaceous fruits (n = >750 species) during this project (R. Copeland, unpubl. data). Lepidopteran species and their parasitoids make up a high percentage, and yet relatively poorly known component, of the guild of frugivorous insects. Previously, *Carposina chersodes* (Meyrick) (Carposinidae) and the common orchard fruit pest *Cryptophlebia leucotreta* (Meyrick) (Olethreutidae) were reared from *Olea europaea* ssp. *cuspidata* in eastern Africa (Greathead, 1976) and, in South Africa, Munro (1924) reported *Hendecasis* sp. from *Chionanthus foveolatus* and *O. woodiana* ssp. *woodiana.*

Fruits of the Oleaceae provide one example of the diversity of insects exploiting a largely overlooked larval resource. While the literature on forest herbivores is, by comparison, voluminous, little attention has been paid to the guild of frugivorous insects and their natural enemies. There may be several reasons for this. Certainly it is easier to consistently find leaf eaters in evergreen and, for that matter, deciduous tropical forest, whereas the search for fruits must be timed with greater precision. And fruits, such as those described in this report, may also be less seasonably reliable. However, while the insect fauna associated with leaves and stems is much richer than that of insects exploiting fruits, the latter comprise a significant portion of tropical insect biodiversity and deserve much closer attention.

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