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CONTENTS

ADDITIONS TO THE FISH FAUNA OF PAPUA NEW GUINEA—I

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ABSTRACT

Eleven species of fish not previously found in Papua New Guinea waters are here recorded. These species belong to the families Carangidae, Lutjanidae, Sparidae, Lethrinidae, Callionymidae, Opistognathidae, Cepolidae and Pholidichthyidae.

INTRODUCTION

SINCE 1961 when the Fisheries Division of the Department of Agriculture, Stock and Fisheries was moved to Kanudi, near Port Moresby, a reference collection of fishes has gradually been formed. Many of the fish specimens were obtained in surveys carried out for the Fisheries Division by the M.V. *Climacs* in 1962, and by the F.R.V. *Tagula* in 1965. In addition, commercial prawn trawlers, research surveys of reefs, and surveys in fresh water, have yielded a large number of species of fish. In recent years specimens have been added from surveys carried out by the fisheries research vessels *Tagula*, *Rossel* and *Maragili* and the privately owned vessel *La Pinta*. Collections have also been made by staff of the Fisheries Research Station.

The fish collection presently contains some 800 of the 1,000-plus species recorded from Papua New Guinea by Munro (1967). In addition to these are some 240 species which have been previously unrecorded from Papua New Guinea. One hundred and ten of these have been already found in West New Guinea, or the Solomon Islands (Munro 1958 and 1967), and the remainder are new to the whole New Guinea region.

Kailola (1971) has recorded 22 of these species, all from experimental trawling carried out at Yule Island in Papua in 1969-1970. The present paper lists 11 more, from various localities in Papua New Guinea, and is the first in a series of papers covering previously unrecorded species held in the Kanudi collection.

Family CARANGIDAE
CARANX RADIATUS Macleay

Caranx radiatus **Macleay, Proc. Linn. Soc. N.S.W., V 1881, p.537.**

D.i; VII-VIII; I, 21-22. A.II; I, 17-20. P.ii, 19-20. V.I, 5. G.R. 12-13 + 24-27.

Body oval, depth 2.5-3.0, head 3.4-3.6, eye 3.3-3.7, equal to snout, and with adipose eyelids which posteriorly advance as far as the pupil. A single row of slightly curved teeth in both jaws; behind those in the upper jaw, is a thin band of villiform teeth. Fine teeth on palatines, vomer and tongue.

Scales cover the body except for a round patch on the pectoral fin base, and on the isthmus. Arch of lateral line high, 1.4-1.9 in straight part of lateral line, which has 40-44 scutes, and commences below the fourth or fifth dorsal ray. Widest scute 1.8-2.9 in eye. Soft dorsal and anal fins with high basal sheaths, behind which rays fit when depressed. The filamentous rays are produced to a varying degree beyond fin membrane, middle ones longest (fifth D.ray 2.1-4.2, and fifth A.ray 2.3-7.5, both in standard length). Pectorals falcate 2.9-3.2 in standard length. Ventrals 0.9-1.8 in head and usually reach anal spines, though are produced as far as fifth anal ray in one specimen (F0456).

Colour of preserved specimens brown or silvery below, darker above. A dark brown spot on operculum above the angle. First dorsal fin dusky. Other fins pale, some with brown on the filaments. Tip of upper caudal lobe dark brown.

Material examined

F0796 One specimen trawled between Otomata and Beagle Bay, Papua. (Lat. 9°53'S., Long. 147°33'E.). 5-15 fms. 7-6-1961. Total length 142 mm.

F01151 One specimen trawled at Orangerie Bay, Papua. (Lat. 10°22'S., Long. 149° 36'E.). December, 1962. Total length 151 mm.

F0456 One specimen trawled at Yule Is., Papua. (Lat. 8°46'S., Long. 146°31'E.). March, 1963. Total length 180 mm.

F0860 Three specimens trawled in Gulf of Papua, February, 1966. Total lengths 138 mm, 155 mm and 159 mm.

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Remarks

McCulloch (1915, p.133) says there is no procumbent spine before the spinous dorsal, and Munro (1960, p.130) is doubtful. All our specimens have a definite spine. Also the number of dorsal spines varied from 7 to 8. This species is reported by Marshall (1964) from North Queensland, Northern Territory and Western Australia. A new record for Papua.

CARANGOIDES HUMEROSUS (McCulloch)

Caranx humerosus **McCulloch, Zool. (biol.) Results Fish Exp. "Endeavour" III, part 3. 1915, p.137, pl. 25.**

D.i; VIII; I,21. A.II;I,18. P.i,19. V.I.,5. C.17 divided rays. G.R. 9 + 17 (or 8 + 1 + 17).

Depth 2.4, head 3.3, eye 3.5, slightly larger than snout, and interorbital, which latter is 3.6 in head. Villiform bands of teeth in jaws made up of three or four series of fine teeth, those in outer rows slightly larger and curved. Fine teeth present on palatines, vomer and tongue. Maxilla broad posteriorly, its expansion 1.7 in eye, and extends to below hind edge of pupil. Naked area on breast anterior of a line from behind pectoral base to halfway along ventral fins. Lateral line with a low arch 1.2 longer than straight part, which commences below 11th dorsal ray and bears 30 or 31 scutes. Spinous dorsal not high, fourth spine 2.8 in head length. Depth between first dorsal and ventral fins less than soft dorsal base. Lobes of second dorsal and anal fins falcate. Ventrals reach anal spines.

Colour of preserved specimen light brown, with five broad vertical bands, first below spinous dorsal, and others below soft dorsal. A large dark oval blotch on shoulder, another on operculum. Spinous dorsal black. Other fins dusky, darker on the caudal, dorsal and anal lobes. Ventrals dark brown.

Material examined

F02025 One specimen trawled by M.V. *Climacs* at Yule Is., Papua. November 1962. Total length 114 mm.

Remarks

Marshall (1964, p.224) states that *C. humerosus* is only known from the Queensland coast north of Gladstone, and four specimens in the Australian Museum, Sydney, (Reg. No. I.15557-106) caught in September, 1963, are from the Gulf of Carpentaria. Capture of this species at Yule Is. significantly extends its range northwards. A new record for Papua.

CARANGOIDES AUROGUTTATUS (C.V.)

PLATE I

Caranx auroguttatus **(Ehrenberg) Cuvier and Valenciennes, Hist. nat. Poiss. IX. 1833, p.71.**

D.I;VIII;I,26. A.II;I,22. V.I,5. P.ii,19. G.R. removed.

Body oval, depth 2.6, head 3.4, pointed. Eye rather small, 5.4 in head and 2.2 in snout. Interorbital high and sharply convex, 1.8 broader than eye, and slightly shorter than snout. Preorbital and eye equal. Mouth oblique, its gape in a line with the lower part of pupil. Teeth in jaws in villiform bands, present also on vomer, palatines and tongue.

An oval naked area on pectoral fin base. On ventral surface of breast are three more naked areas; the first as a narrow band on isthmus, the others as oval patches at bases of ventral fins. The latter are separated from the naked isthmus by a band of scales. Ventral naked areas barely extend up on sides (see Smith 1972, *Plate* 30). Rest of body heavily scaled, scales extending onto anterior lobes of anal and dorsal fins, and over lower rays of caudal and pectoral fins. Soft vertical fins with a scaled basal sheath, ending 2/3rd way along fin bases.

Lateral line with a long, low arch ending below 11th or 12th dorsal ray and 1.9 longer than straight part. Straight part with 22 weak scutes, the broadest of which is contained almost four times in eye. Soft dorsal and anal fins with short lobes, about as high as first dorsal, whose third spine is 3.8 in body depth. Pectoral fin long and falcate, 1.3 longer than head, and reaching straight part of lateral line. Ventrals 2.2 in head.

Colour of fresh specimen greenish blue above, becoming silvery with a greenish sheen below. Body covered with numerous golden-orange spots about as large as pupil. Upper part of head brown, a fine black ring encircling eye. Fins dark green to black, pectorals lighter. Colour of preserved specimen a rich brown with green shades. Black over upper part of head. Fins dark.

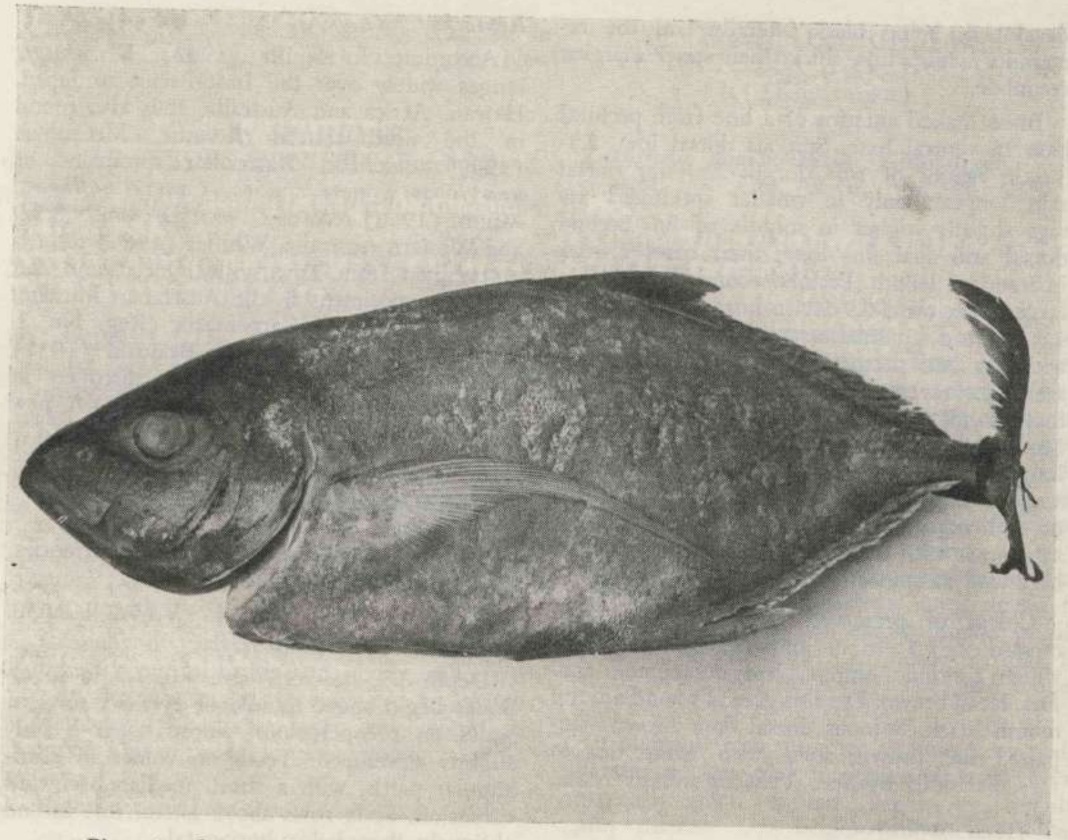

Plate 1.—*Carangoides auroguttatus* (C.V.) Reg. No. F0865. Total length 346 mm

Material examined

F0865 One specimen trolled off Kavieng, New Ireland. (Lat. 2°35'S., Long. 150° 48'E.). February, 1970. Total length 346 mm.

Remarks

Weber and de Beaufort (1931) have listed this species as occurring in the Red Sea, Singapore, Java and as far east as Ternate in the Moluccas Islands. Smith (1972) records it also from the Western Indian Ocean. Our specimen thus represents a significant range extension. I have compared our specimen with specimens of *C. fulvoguttatus* Forskal in our collection, and find them quite distinct. A new record for New Guinea.

* A paper by Reuben, 1968 (*J. Mar. biol. Ass. India* 10 (1):133-151) was received after this manuscript was prepared. According to him, *U. uraspis* is the juvenile of *Uraspis helvola* (Foster, 1775, in Bloch and Schneider, 1801).

URASPIS URASPIS (Gunther)*

Caranx uraspis **Gunther, Cat. Brit. Mus. II 1860, p.444.**

D.i; VIII; I, 26-28. A.II; I, 20-21. P.ii, 20-21. V.I,5. G.R.5 + 14-15.

Depth 1.8-2.1 head 2.7-3.1 snout subequal to eye (0.9-1.3), which is 2.9-3.8 in head and slightly smaller than interorbital. Eye 1.2-1.7 in postorbital. A sharp median ridge commences over front of eyes and continues along dorsal profile to origin of dorsal fin. Vestigial adipose lids on eye. Teeth in jaws sharp, slender and conical, strongly curved. Teeth in one or two series in upper jaw, and in two series in lower jaw, where in some specimens the outer row is discontinued posteriorly. No teeth at symphysis of jaws. Rest of mouth edentate. A thick white membrane on tongue, roof and floor of mouth. Sides of tongue black posteriorly. Velum of upper and lower jaws well developed, being black laterally and the remainder white. Lips thick, their inner margins crenulate.

Breast naked anterior of a line from pectoral base to ventral base. Spinous dorsal low, 2.5-3.6 in height of soft dorsal. Anterior dorsal rays longest; only in smaller specimens are rays slightly higher in middle of fin. Second dorsal and anal fins long, their bases 2.1-2.2 in standard length. Pectoral rounded, falcate in largest specimen, 0.9-1.1 in head. Ventrals 0.9-1.8 in head. In smaller specimens the ventrals are long and pectorals short. In larger specimens, the reverse occurs. Pectoral fin not more than twice longer than ventral (0.9-1.9). Moderately arched part of lateral line always longer than straight part (1.2-1.6 times straight part), which commenced opposite 14th or 15th dorsal ray. Scutes 30-32, many keeled, sometimes with the apices directed forward and backward as spines.

Colour of preserved specimens pale, body crossed by 7 to 9 brown vertical bands, which continue onto second dorsal and anal fins. Head brown. Eye-lids grey; lips and around mouth black. Spinous dorsal dark brown. Unpaired fins brown, some with white tips to rays. Pectorals hyaline. Ventrals usually black.

Material examined

F02308 One specimen trawled at Yule Is. November 1962. M.V. *Climacs*. Total length 105 mm.

F02026 One specimen trawled at Yule Is. February, 1963. Total length 134 mm.

F02320 One specimen trawled between mouths of Sepik and Ramu Rivers, New Guinea. (Lat. 4°00'S., Long. 144°40'E.). September, 1965. Total length 138 mm.

F02326 One specimen trawled in Gulf of Papua. 14-2-1969. Total length 109 mm.

F0304 One specimen trawled at Orokolo Bay, Papua. (Lat. 7°48'S., Long. 145° 04'E.). February 1969. Total length 166 mm.

F01407 Two specimens trawled in three fms at Goaribari Is., Papua. (Lat. 7°50'S., Long. 144°15'E.). 10-2-1969. Total lengths 106 mm and 130 mm.

F01493 One specimen trawled by the *Falaika* in Gulf of Papua. March, 1969. Total length 114 mm.

Remarks

According to Smith (1962) *U. uraspis* ranges widely over the Indo-Pacific to Japan, Hawaii, Africa and Australia. It is also found in the north-western Atlantic. McCulloch (1909) described Australian specimens of *uraspis* as a new species, *Caranx hullianus*. Munro (1960) records *U. uraspis* from N.S.W. and Western Australia, Whitley (1964) records a specimen from Townsville, Queensland and there are specimens in the Australian Museum from the Gulf of Carpentaria (Reg. No. I. 15557-113). Weber and de Beaufort (1931) record *uraspis* from Ambon. Its discovery in Papua New Guinea seems inevitable. A new record for Papua New Guinea.

Family LUTJANIDAE
LUTJANUS BIGUTTATUS (C.V.)

***Serranus biguttatus* Cuvier and Valenciennes, Hist. nat. Poiss. VI, 1830, p. 507.**

D.XI,12. A.III,8. P.ii,14. V.I,5. L.lat.50. Tr.5 + 13 or 14. G.R.8 + 18.

Depth 3.3, head 2.7, eye 4.0, 1.2 in snout. Scales begin above middle of eye. Six rows of scales on preoperculum, whose notch is only slightly developed. Teeth on vomer in a triangular patch, with a short, median backward extension. Scale rows above lateral line ascend obliquely, those below horizontal.

Colour of fresh specimen brown on back, separated from the paler lower half by a maroon band from snout through eye to upper caudal base. Lower half silvery, becoming orange on belly. Two pearly blotches above lateral line, one below anterior dorsal rays. Vertical and caudal fins bright yellow-orange; paired fins pale yellow, almost hyaline. When preserved, the brown back is sharply divided from the white lower surface of sides. Fins yellow.

Material examined

F02107 One specimen seine-netted at Motupore Island in Bootless Bay, Port Moresby. (Lat. 9°33'S., Long. 147°14'E.). 23-9-1971. Total length 171 mm.

Remarks

This species is found throughout south-east Asia to India and the Philippines, and has been recorded from Waigeu and the Solomon Islands. The Australian Museum also has specimens from north of Maiwara, New Guinea

(Lat. 5°12'S., Long. 145°49'E.) collected in 1969. A new record for Papua and New Guinea.

Family SPARIDAE
ARGYROPS SPINIFER (Forskal)

Sparus spinifer Forskal, Descript. Animalium, 1775, p.32.

D.XI,10. A.III,8. P.ii,12,i. V.I,5. L.lat.51-55 Tr. 6+17-18. G.R.6-7+10.

Depth 1.7-2.0, head 2.8-3.1, eye 2.5-2.9, being 1.1-1.3 in snout and 1.2-1.4 larger than interorbital. Head profile steeply convex. First two filamentous dorsal spines (numbers II and III) reach past caudal fin tip. Pectoral 1.1-1.3 times head, reaching to fourth anal ray. Ventral reaches past anal fin origin, occasionally as far as first anal ray, and is more or less equal to head. First anal spine 2.3-2.9 in second anal spine. Least depth of caudal peduncle 1.0-1.2 in its length.

Colour of preserved specimens pink with five dark vertical bands across body, and a sixth from the interorbital, through eye, to isthmus. Membranes of dorsal, anal and ventral fins dusky. Tips of caudal lobes brown.

Material examined

F0221 One specimen trawled at Daru Roads, Papua. (Lat. 9°05'S., Long 143° 20'E.). 19-1-1961. Total length 83 mm.

F0326 Two specimens trawled north-west of Cape Possession, Papua. (Lat. 8°35'S., Long. 146°23'E.). 24-1-1961. Total lengths 94 mm and 117 m.

F01428 One specimen trawled inside Jones Reef, 8½ cables north of Tamina Point, Porlock Harbour. (Lat. 9°00'S., Long. 149°06'E.). 20 fms. 2-12-1962. Total length 97 mm.

F02253 One specimen trawled by F.R.V. *Maragili* at Yule Is., Papua. 19 fms. 21-11-1970. Total length 80 mm.

F02254 One specimen trawled by F.R.V. *Rossel* at Yule Is., Papua. 15 fms. 23-1-1971. Total length 126 mm.

Remarks

Widespread in the Indian Ocean and throughout South-East Asia to Queensland. A new record for Papua.

Family LETHRINIDAE
LETHRINELLA XANTHOCHEILUS (Klunzinger)
PLATE II

Lethrinus xanthocheilus Klunzinger, Verh. zool. bot. Ges. Wien., Vol. 20, 1870, p. 753.

D.X,9. A.III,8. P.ii,10,i. V.1,5. L.lat.48. Tr.4½ +16 G.R. (removed).

Depth 3.4-3.5, head 3.0-3.1, eye 5.0. Eye in snout 2.7-2.8, in suborbital 2.2 and in interorbital 1.3-1.4. Snout 1.8 in head. Four large canines in front of each jaw, followed by a single row of shorter conical teeth which become squat and pointed posteriorly. A villiform band of teeth behind outer row. Posterior nostril about midway between snout tip and hind margin of head. Head profile slopes gently up from snout to before eyes, where it bends to form a very flat interorbital, behind which it is almost horizontal until dorsal fin origin. Upper edge of eye in dorsal profile. Pectoral fin short, 1.5 in head. Ventral fin 1.7 in head. Soft anal base 2.5-2.7 and longest anal ray 3.1-3.3, both in head.

Colour of fresh specimen: yellow-green body, darker on back, pink to orange ventrally. Head generally green to black, broken by irregular grey patches. Lips bright yellow, upper part of maxilla vermillion. Inside of mouth and of operculum scarlet. Chin grey, pink anteriorly. Opercular edge also scarlet. Brown spinous dorsal fin flushed with russet-red. Soft dorsal pinkish-orange. Anal fin similar though has yellow shadings, and its lower part is pale green. Ventral fin bright green, its leading edge orange. Pectoral fin orange, its base bright yellow. On upper and lower portions of pectoral base are scarlet patches, the lower one smaller. Pectoral fin socket also scarlet. Caudal fin pale green, its outer edge pinkish-orange. When preserved, body grey, scales on back and sides outlined in dark brown forming a latticework. Fins light brown. Head dark brown to black. Lips white.

Material examined

F02096 One specimen taken by handline at night from the *Claire M* on Musgrave Reef, Yule Is., Papua. August, 1972. 5 fms. Total length 520 mm.

plus One specimen bought at Koki Market, Port Moresby, on 24th November, 1972. Total length 498 mm.

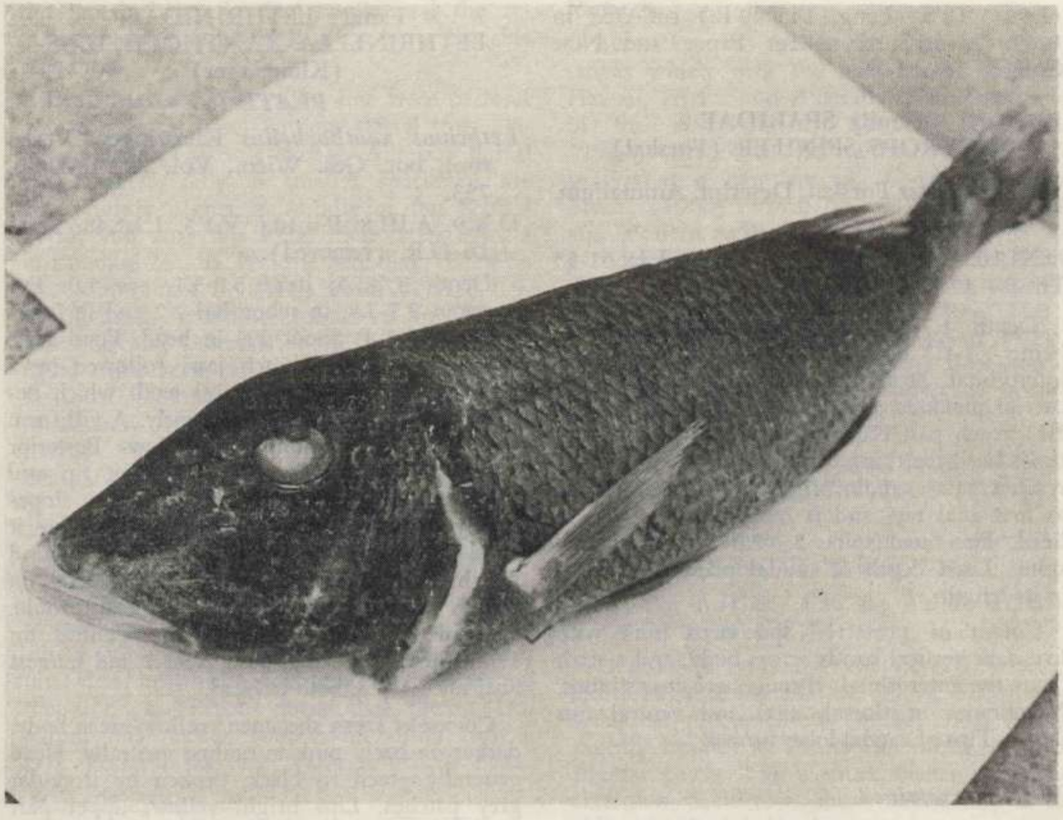

Plate II.—*Lethrinella xanthocheilus* (Klunzinger) Reg. No. F02096. Total length 520 mm

Remarks

These specimens are immediately distinguished as *L. xanthocheilus* by the flat interorbital, and the eye in dorsal profile. When fresh, the dark head, bright yellow lips and scarlet on operculum, pectoral base, and in pectoral socket, make the fish immediately recognizable as *L. xanthocheilus*, as illustrated by Smith (1959) on *plate* 22, *figure B*. Smith (loc. cit.) gives its distribution as "from 14°00'S. northwards in East Africa, and at several islands in West Indian Ocean . . . " (p.292). Fowler (1933) gives locality as "Red Sea". (p.52) and Silas and Toor (1961) record *L. xanthocheilus* from the Andaman Sea. The Papua New Guinea specimens thus represent a significant range extension. A new record for Papua.

During October and November, 1972 the author observed several specimens of a lethrinid fish at Koki Market, Port Moresby which were almost identical with Smith's figure of *L. xanthocheilus*. All had the very flat interorbital and eye in dorsal profile characteristic of *xanthocheilus* and flat to slightly rising dorsal profile behind eye. Data from two specimens is given in *Table* 1 and compared with *xanthocheilus*.

These two specimens were practically identical in colour with the Yule Is. specimen of *L. xanthocheilus*, except that the lower scarlet spot on the pectoral fin base was absent, and the head was lighter. The hind nostril in these specimens was distinctly nearer the snout tip than to the opercular edge: according to Smith (1959, p.291), this is characteristic of young specimens of *xanthocheilus*, as well as for specimens of all ages of *Lethrinella variegatus* (Val.).

Silas and Toor (1961) describe two specimens of a lethrinid fish very similar to my smaller specimens, to which they give the name *Lethrinella* prox. *xanthocheilus* (p.210 and 211). In their specimens the upper red axillary

Table 1.—Comparison of two specimens of *Lethrinella* with a specimen of *L. xanthocheilus* (Klunzinger)

Character	Reg. No. F02360 27-10-72	Reg. No. F02335 7-11-72	Compared to L. xanthocheilus, Reg. No. F02096
Total length (mm)	292	400	520
Standard length (mm)....	231	324	445
Position of hind nostril	nearer to snout tip than opercular edge	nearer to snout tip than opercular edge	approx. midway between snout tip and opercular edge
Hind teeth in jaws	short and conical	short and conical	squat and pointed
Eye in snout	1.7	2.4	2.7
Eye in head	3.8	4.7	5.0
Eye in suborbital	1.5	2.0	2.2
Eye in interorbital	1.0	1.2	1.3
Eye in bony interorbital	0.7	0.9	1.0
Snout in head	2.3	2.0	1.8
Pectoral in head	1.4	1.5	1.5
Ventral in head	1.5	1.7	1.7
Soft anal base in head	2.5	2.4	2.7
Longest anal ray in head	2.9	3.0	3.1
Depth	3.6	3.6	3.4
Head	3.1	3.1	3.0
Gill Rakers	4+5	4+5	removed

spot was on scales just above, not on, the pectoral base. For neither specimen, nor their 593 mm specimen of *xanthocheilus*, do they mention a red spot on the lower part of the pectoral base.

It is quite likely that all seven specimens of *Lethrinella* here discussed belong to *xanthocheilus*, as there is apparently no other species with a colour pattern so close to theirs, and they all have the flat interorbital, and upper margin of the eye in the dorsal profile, characteristic of *xanthocheilus*. The only variations in colour between the seven specimens are the presence or absence of the lower scarlet spot on the pectoral base, and the lighter head in three of the New Guinea specimens. The relative body proportions also vary, apparently with size (shown in *Table* 2), but this is a phenomenon not uncommon in lethrinid fish (Fowler 1933, p.4; Silas and Toor 1961, p.208 and Weber and de Beaufort 1936, p.431). A detailed study of a whole series of specimens is needed however, before a firm decision can be reached.

Family CALLIONYMIDAE
DACTYLOPUS DACTYLOPUS (C.V.)

***Callionymus dactylopus* Cuvier and Valenciennes. Hist. nat. Poiss. III, 1837, p.310.**

D.IV;8. A.7. P.i,17,i. V.I+i,4.

Depth 5.3, head 3.8, eye 3.1, longer than snout (0.8) and 3.4 times larger than interorbital. Preopercular process with two or three spines along its outer edge and two smaller spines on its inner edge. Lateral line unbranched. Soft dorsal fin high, its height longer than head length. First detached ventral ray as long as pectoral fin.

Colour of preserved specimen brownish above and paler below; light ocelli scattered over back, sides and head. First dorsal with a black, light-ringed ocellus midway on membrane between third and fourth spines. Soft dorsal flecked with darker brown, roughly formed into five or six longitudinal bands. Anal fin similar, with four bands, which break into spots on outer margin. Five transverse rows of spots on pectoral and caudal fins, disappearing on lower half. Ventral variegated with dark.

Material examined

F02156 One specimen trawled near Yule Is., Papua. November, 1962 by M.V. *Climacs*. Total length 90 mm.

Remarks

Found through South-East Asia, the Philippines and from Western Australia and Queensland. A new record for Papua.

Table 2.—Body proportions in thousandths of standard length for seven specimens of *Lethrinella*

Standard Length (mm)	160*	224*	231	324	418	445	593†
Head length	356	379	323	319	321	326	296
Snout length	169	192	143	163	180	180	176
Eye diameter	106	105	86	68	64	61	60
Interorbital	100	118	80	84	92	90	73
Bony Interorbital	—	—	58	60	62	61	—
Snout to post. nostril	156	183	128	145	163	150	—
Post. nostril to hind margin of head	225	232	201	178	157	164	—
Pectoral length	269	246	234	209	209	209	181
Ventral length	231	210	213	185	186	198	154
Soft anal base	131	138	128	134	127	121	102
Longest anal ray	103	98	112	105	94	99	82
Greatest body depth	306	321	282	276	281	292	248

*figures taken from Table I of Silas and Toor (1961) for *Lethrinella* prox. *xanthocheilus*.

†it is difficult to explain the omission of the figure for the 593 mm specimen *xanthocheilus* in Table I of Silas and Toor (loc. cit.). The figure appearing below the column headed '"*xanthocheilus*" are actually those for the smallest example of L. *microden* (Val.) studied by Silas and Toor. For the purpose of comparison here, the present author has calculated the actual measurements and then the body proportions in thousandths of the standard length, from the body ratios for *xanthocheilus* in the text (p.210).

Family OPISTOGNATHIDAE
TANDYA LATITABUNDA (Whitley)
PLATE III

Tandya latitabunda Whitley, Rec. Aust. Mus., 20(1) 1937, p.21. pl.2, fig. 2.

D.XII,18. A.I,15. P.i,22-23. V.I,5. C.12 branched rays. L. lat. 50-54. Scale rows above lateral line to tail base 98-108. Tr. 5+1+26-28. G.R. 6-8+15-16. Br.6.

Depth 2.9-3.2 (belly distended in one specimen). Head 2.6-2.7, eye 2.9-3.6, 3.8-4.4 larger than interorbital, and 4.1-5.6 larger than preorbital.

Head bulbous; body compressed and slightly tapered, caudal peduncle depth 8.2-8.8 in standard length. Eyes large and circular, in front third of head. Maxilla extends almost as far as preopercular ridge. One row of slender canines in both jaws, 20-33 each side of symphysis in upper jaw, and 21-28 on each side in lower jaw. An inner row of smaller teeth may be present near middle of jaws: in upper jaw these teeth only in one specimen (14 teeth), and in lower jaw present in all three specimens (7-24 teeth). Large teeth on pharyngeal bones. Symphysis and palate edentulous.

No scales on head, neck and in region anterior to ventral and pectoral fin bases. Rest of body with cycloid scales, present also on pectoral base. Lateral line almost straight, ending below fourth or fifth dorsal ray. Dorsal fin originates above upper insertion of operculum. Anal fin height subequal to that of soft dorsal. Caudal and pectoral rounded, the latter 1.7-2.0 in head length. Ventrals 1.5-1.7 in head.

Colour of preserved specimens: head light brown, only markings being a black ring around eye, black on inside of maxilla, and under maxilla on mandible, and a black streak below opercular flap. Eyes dark blue. Body pale, with two rows of large black blotches. The first row consists of five blotches immediately below the

Plate III.—*Tandya latitabunda* Whitley. Reg. No. F01308. Total length 210 mm dorsal fin and extending onto fin. Second row of five blotches runs along middle of sides, the first just behind opercular flap, last three extending downwards to above anal fin. A large blotch under pectoral fin. Caudal peduncle crossed by a black band. Anal fin and outer third of dorsal fin black. A black band across base of caudal rays, the rest of fin mottled with black. Pectoral and ventral fins pale brown, the former with a vertical black band in proximal half.

Material examined

F02040 One specimen from Yule Is., Papua. Trawled by M.V. *Climacs*, November, 1962. Total length 190 mm.

F01308 Two specimens from Yule Is., Papua. Trawled by F.R.V. *Tagula* in 15 fms over a mud bottom. 20-5-1967. Total lengths 210 mm and 114 mm.

Remarks

Described in 1937 from one specimen (Aust. Mus. Reg. No. IA. 6958) from Port Newry, north of Mackay, Queensland, this species is rare, as Marshall (1964) says it is " . . . known only from the unique holotype . . . " (p.328). As far as I can ascertain, the three specimens described above, plus two specimens in the Australian Museum (Reg. I. 15557-210) from the Gulf of Carpentaria in 1963 are the only other representatives of the species found since 1937. A new record for Papua.

Family CEPOLIDAE
ACANTHOCEPOLA ABBREVIATA (C.V.)

Cepola abbreviata **Cuvier and Valenciennes, Hist. nat. Poiss. X, 1835, p. 403.**

D.74-79. A.78-81. P.19-20. V.I,5, the innermost ray attached to the body. Scale rows from angle of operculum 176-230*. G.R. 15-17+29-32. (* the number of transverse scale rows, as well as the depth and head ratios, are noticeably higher in the largest specimen.)

Depth 6.7-10.6, head 7.1-9.1, body very compressed and elongate. Eye 2.7-3.4, 1.3-1.8 larger than interorbital, which is 4.5-5.0 smaller than head. Eye 1.7-2.6 longer than snout, which is 6.0-7.0 in head length. A prominent hump on snout. Teeth in upper jaw 33-36 on each side, an edentulous space at symphysis, the anterior teeth being larger and curved. Maxilla 1.8-2.1 in head, and ends below middle of pupil. Preoperculum with a sharp triangular spine at its angle and three or four antrorse spines on the lower border (reduced in largest specimen). Lateral line curves upwards from insertion of operculum to meet dorsal fin base at the fifth ray, whence it continues to caudal. Body scales in regular rows becoming larger posteriorly in the largest specimen. Dorsal and anal united with caudal by membrane. Pectoral rounded, 1.4-1.6 in head length. Caudal fin tapered.

Colour of preserved specimens off white or creamy, the only marking being a thin black margin to the anal, caudal and posterior third of the dorsal fins (not present in largest specimen).

Material examined

F0708 One specimen from between the Ramu and Sepik River mouths trawled by F.R.V. *Tagula* in September, 1965. Total length 342 mm.

F01133 One specimen trawled between Yule Is. and Cape Possession, Papua between 26th and 28th September, 1967. Total length 197 mm.

F02262 One specimen trawled near Goaribari Is., Gulf of Papua. 12-2-1969. Total length 157 mm.

Aust. Mus. Regd. No. I. 1555-209. One specimen from the Gulf of Carpentaria, at Lat. 15°53'S., Long. 140°55'E. in 5 fms. 21-11-1963.

Remarks

Recorded from India, China, Philippines and as far east as Salajar in Indonesia, and the "Molucca Sea" (Gunther 1861, p.488). The occurrence of *C. abbreviata* in Australian waters has been reported by Haysom (1957) on a specimen captured near Townsville, Queensland in 1955, and by Mees (1959) on two specimens from Exmouth Gulf, Western Australia, in October, 1958. The Australian Museum specimen (I. 1555-209) was collected in the Gulf of Carpentaria in November, 1963. The species has not been found east of Papua New Guinea and is a new record for these waters.

Family PHOLIDICHTHYIDAE
PHOLIDICHTHYS LEUCOTAENIA (Bleeker)

PLATE IV

***Pholidichthys leucotaenia* Bleeker, Natuurk. Tijdschr. Ned-Indie XI, 1856, p. 406.**

D.66-77. A.49-62. P.15-16. V.I, 2. C.8-10. G.R.4-6+1+7-10 (gill raker present in angle).

Body tapering, compressed posteriorly, its depth 9.1-11.3. Head 5.5-5.9, eye 5.4-6.3, subequal to interorbital (1.0-1.2) and to snout (snout in eye 0.9-1.1). Eye in front half of head, 3.1-4.3 in postorbital head length, mouth almost horizontal. Maxilla ends below posterior edge of eye. Teeth in both jaws pointed conical, in four or five overlapping rows (*Figure* 1) with a few larger canines at front of jaws. Conical teeth also present on pharyngeals, but none on vomer, palatines or tongue.

Body naked, no lateral line, numerous pores on head (*Figure* 2, a and b). Dorsal and anal fins united with caudal; dorsal beginning just anterior of the opercular margin. Caudal slightly rounded. Ventral fin 0.8-1.9 times the eye. In some specimens one ventral fin is noticeably shorter than its partner. Pectoral fin rounded, 0.8-1.2, in snout plus eye. Head in distance from anal fin origin to snout 2.1-2.4. Anal and dorsal fins moderately high, thrice in body depth.

Colour of preserved specimens off-white to pale pink, with a wide black band from snout through eye, across pectoral base, to tail base whence it continues to caudal fin margin. A second black band runs from snout along dorsal profile and follows the base of the dorsal fin almost to caudal fin. Dorsal and caudal fins dusky. Other fins hyaline. Snout and front of lips black. Iris black.

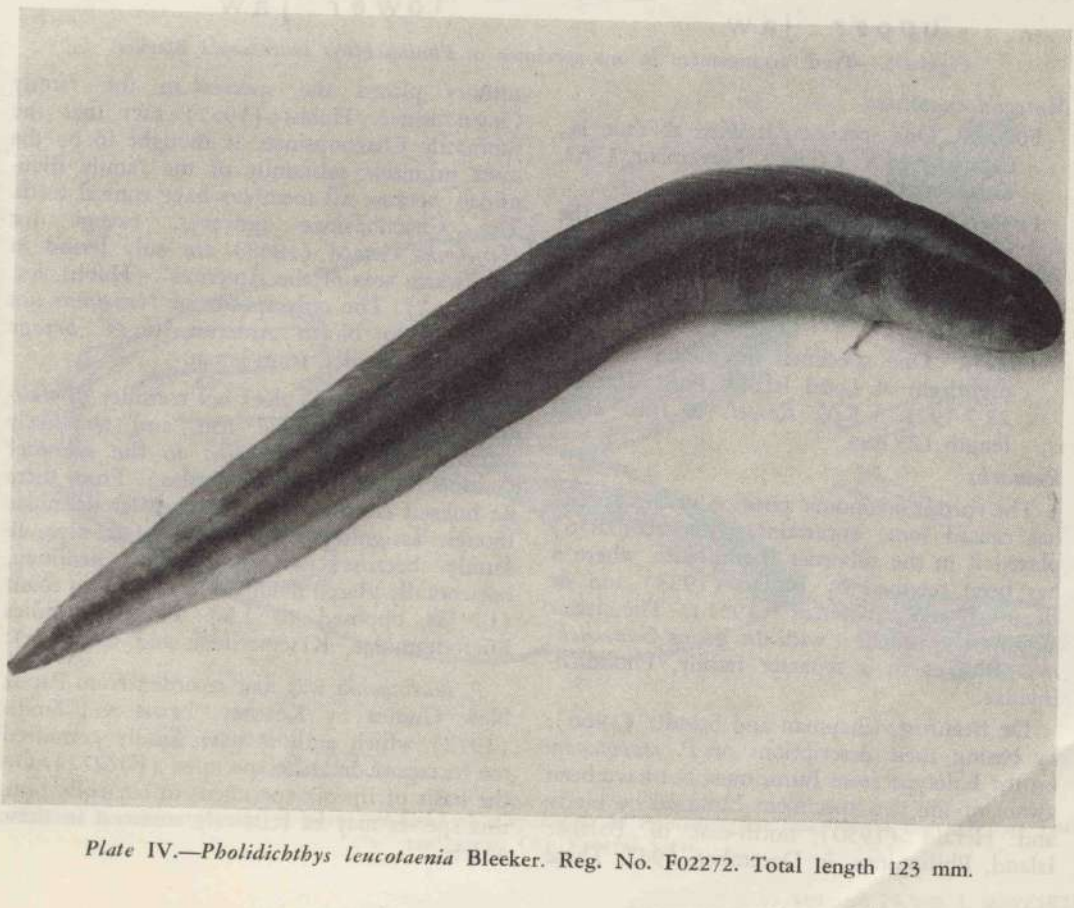

Plate IV.—*Pholidichthys leucotaenia* Bleeker. Reg. No. F02272. Total length 123 mm.

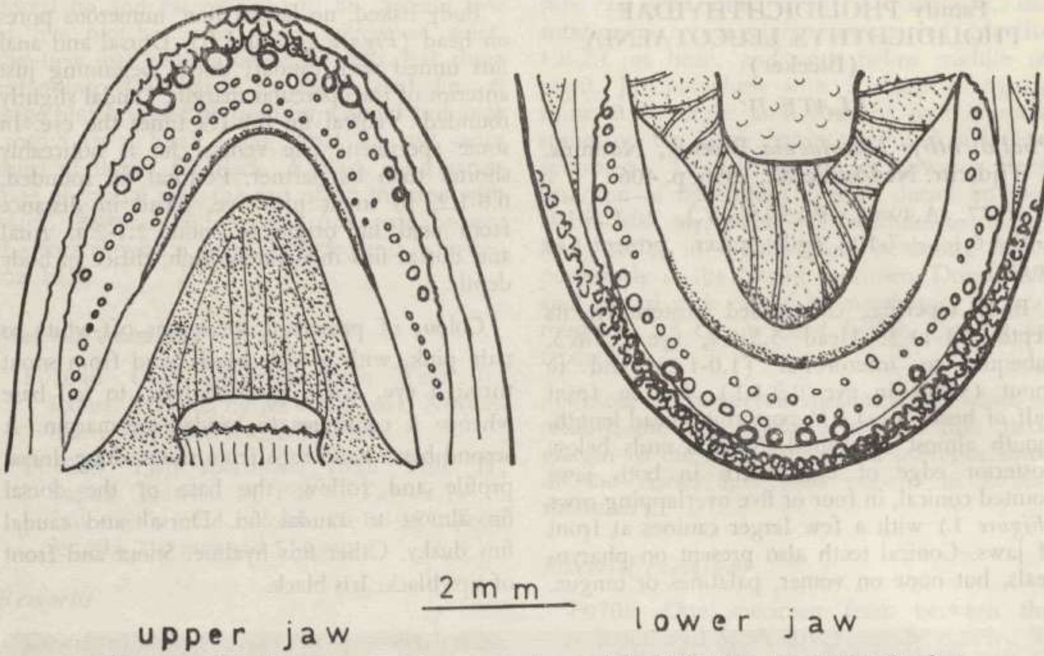

Figure 1.—Teeth arrangement in one specimen of ***Pholidichthys leucotaenia*** Bleeker.

Material examined

F02038 One specimen trawled at Yule Is., Papua by M.V. *Climacs*. November, 1962. Total length 106 mm.

F0366 Four specimens captured under the wharf at Samarai, Papua. (Lat. 10°37'S., Long. 150°40'E.). April, 1964. Total lengths 130 mm, 123 mm, 131 mm and 123 mm.

F02272 One specimen dip-netted under a nightlight at Local Island, Port Moresby. 22-7-1971. F.R.V. *Rossel*. 10 fms. Total length 123 mm.

Remarks

The correct taxonomic position of this species has caused some uncertainty. Bleeker (1856) placed it in the suborder Blennioidei, where it has been retained by Jordan (1923) and de Beaufort and Chapman (1951). The latter authors also united it with the genus *Gunellichthys* Bleeker in a separate family, Pholidichthyidae.

De Beaufort, Chapman and Schultz (1966), by basing their descriptions of *P. leucotaenia* on the holotype from Buru, must not have been aware of the two specimens captured by Herre and Herald (1950) north-east of Balabac Island, Philippines, in December, 1947. These authors placed the species in the family Chaenopsidae. Hubbs (1952) says that the subfamily Chaenopsinae, is thought to be the most primitive subfamily of the family Blenniidae, because all members have conical teeth. The Chaenopsinae however, except for *Neoclinus* Girard (1858) are only found in the "warm seas of the Americas" (Hubbs, loc. cit, p. 52). The only species of *Neoclinus* not restricted to North America, is *N. bryope* Jordan and Snyder, from Japan.

Schultz (loc. cit.) does not consider *Pholidichthys* as a Blennioid fish, and tentatively refers it and *Gunellichthys* to the suborder Gobiina (superfamily Gobioidea). From there he links it closest to the family Microdesmidae though assigning it the rank of a separate family because of its peculiar dentition, horizontally-placed mouth, and ventral fin count (I,2 as opposed to I,3-5 in the families Microdesmidae, Kraemeriidae and Gobiidae).

P. leucotaenia was first recorded from Papua New Guinea by Kearney, Lewis and Smith (1972) which authors have kindly permitted me to report on their specimen (F02272). On the basis of the six specimens in our collection, this species may be relatively common in these waters.

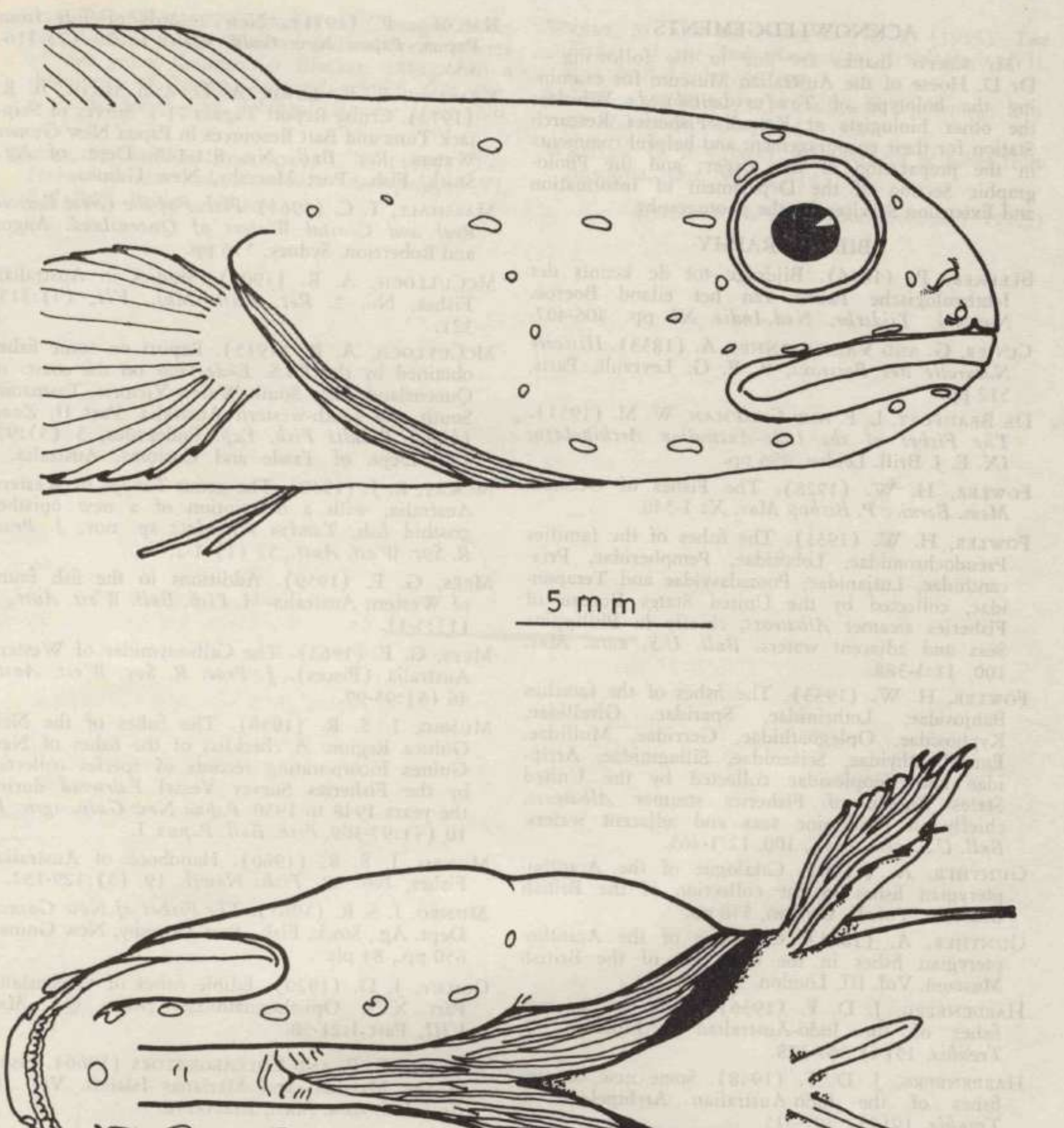

Figure 2.—Arrangement of pores on head of a specimen of *Pholidichthys leucotaenia* Bleeker. (*a*) Lateral view, (*b*) Ventral view

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THE PRODUCTIVITY OF EXOTIC AND INDIGENOUS PIGS UNDER VILLAGE CONDITIONS—PART I

G. L. MALYNICZ*

ABSTRACT

In order to carry out a preliminary assessment of the productivity of various types of pigs under village conditions in the Highlands of Papua New Guinea, 15 British, crossbred and native pigs were given to members of Okiufa Village, near Goroka. The owners were requested to treat them as normal village pigs and to present them for weekly weighing and examination. Treatment of clinical disease was not undertaken.

Thirteen pigs had died by the conclusion of the experiment five months later. Weight gains were non-existent or insignificant. There was no apparent association between mortality and genotype.

INTRODUCTION

THE distribution of so-called "improved" breeds of pigs to village farmers was commenced by the Administration of Papua New Guinea in the late 1940's as part of the Australian Government's programme of reparation for war damage. This programme has developed over the years to one which now produces some 800 pigs per year from Administration stations at Goroka, Erap (Lae) and Rabaul for sale to village farmers. Breeds involved are mainly Tamworth, Berkshire and Large Black, and more lately crosses of these breeds with indigenous pigs.

Although the programme has achieved a grading of indigenous pigs towards "improved types" over many parts of Papua New Guinea, this process has not necessarily been one of "grading up" when one considers the management systems under which the pig must survive and produce. In addition there has been little follow-up of the contribution these pigs have made to village production, although Harvey (1965) indicated high mortalities and very poor growth rates amongst pigs distributed into various villages in the Highlands.

In this trial, a more detailed study of the performance of three types of pigs distributed from the Tropical Pig Breeding and Research Centre was carried out at the village of Okiufa as a preliminary assessment. Okiufa is a village containing some 25 families. It is only three miles from Goroka and many of the men are employed in the town. Coffee is grown as a cash crop and subsistence gardens are maintained by the women.

MATERIALS AND METHODS

Nine male pigs of three breed groups ($\frac{1}{8}$ native x British, $\frac{1}{4}$ native x British, purebred British (Berkshire)) each 13 weeks of age, together with six purebred native male pigs 18 weeks of age were distributed to different members of Okiufa village. Once weekly the pigs were weighed and inspected.

RESULTS

Weekly weight gains are shown in *Table* 1. In *Figure* 1 is shown cumulative mortality over the period of the trial. In *Table* 2 are presented the bodyweights of a number of contemporary native pigs which had not been distributed into villages but remained at the Tropical Pig Breeding and Research Centre and received adequate nutrition.

A mange-like condition of undetermined aetiology was observed in most pigs. It was noticeable that pig numbers 30168 and 38718 (which survived) failed to show symptoms.

Coughing was commonly a premonitory symptom of impending death. Anorexia was a common premonitory symptom of ensuing mortality, usually beginning some days before death. Diarrhoea was observed only once, during the third week of the experiment.

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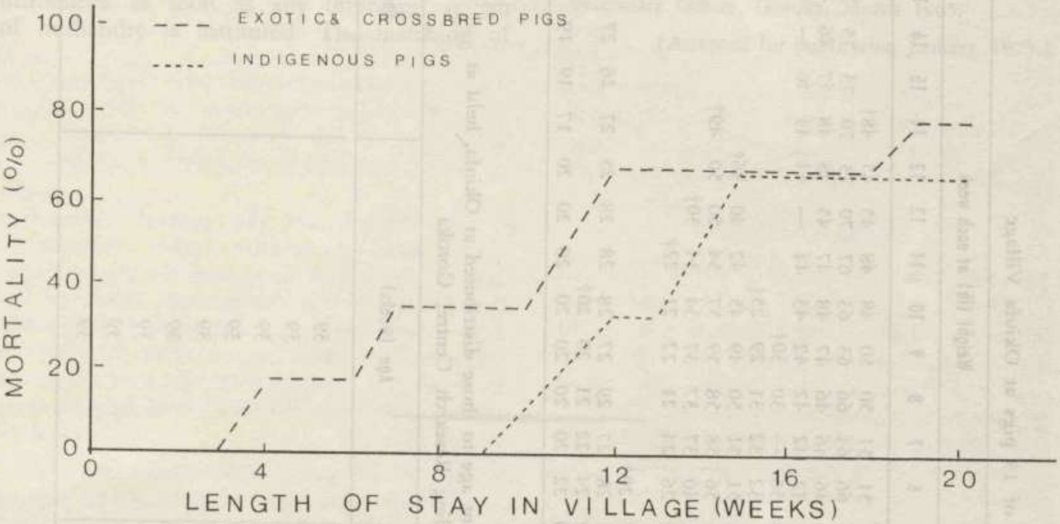
FIGURE 1

CUMULATIVE MORTALITY



Terminally there occurred a change in the tone of the squeal which became very weak. This change in squeal was invariably followed by death.

DISCUSSION

British bred pigs under commercial husbandry conditions should weigh just under 260 lb at 34 weeks of age. The only two surviving improved pigs (30168 and 38718) weighed 78 and 42 lb respectively at this age.

If the weight gains of the native pigs in the trial are compared with their contemporaries under normal husbandry conditions, it is apparent that the degree of stunting among native pigs was much less severe than among the pure and crossbred British pigs. Of particular interest is the low bodyweight of the native pigs under good conditions. It has been estimated at ceremonial "pig kills" that fully grown indigenous pigs weigh in the region of 300 lb. It is interesting to speculate that the low growth potential of native pigs is a fitness characteristic which may increase their survival rate under conditions of nutritional stress.

The mortalities among all groups were extremely high—reaching 80 per cent by the end of the trial. It can be seen from the figures that the mortality of native pigs was somewhat higher than that of British pigs. Whilst this is an unexpected finding, it may be explained by the fact that those people receiving British or crossbred pigs managed them better than those receiving indigenous pigs. It is well recognized among village people that British pigs, while possessing a greater growth potential, are less adapted to local environmental conditions. The very name "susu pik" (milk pig), suggests this recognition. It is therefore quite probable that the possession of a "susu pik" elicits a higher standard of management than that accorded to normal village pigs.

CONCLUSIONS

The programme of pig distribution based on "improved" breeds of pigs was designed to introduce to the indigenous pig population the more productive characteristics of high growth rate and fertility. While the programme has been effective in changing the genotype of a large percentage of Papua New Guinea's pig population, this trial and previously recorded evidence suggest that it is essential that this

Table 1.—Weekly body weights of 15 pigs at Okiufa Village

Group	Ear Tag No.	Breed*	Initial Age (wks.)	Weight (lb) at each week																				
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
A	38593	1/8N x B*	13	48	45	49	53	51	51	51	50	50	48	48	45	45	48†							
A	30168	1/8N x B*	13	56	54	54	—	60	66	64	66	63	63	67	70	73	70	73	75	72	71	73	76	78
A	38711	1/8N x B*	13	44	40	44	45	46	46	46	46	47	48	47	45	48	48	47	46	49	47	45	48	36†
B	38718	1/4N x B	13	38	38	37	44	40	42	42	42	42	43	44	—	44	44	46	—	46	47	45	—	42
B	38713	1/4N x B	13	39	34	37	40	38	36	—	30	30†												
B	38729	1/4N x B	13	33	31	32	35	31	32	32	31	29	25†											
C	30242	B	13	52	48	52	53	46	51	51	50	49	45	42	40	36†								
C	30633	B	13	50	37	52	56	58	56	58	58	59	57	54	50	50	49†							
C	30232	B	13	40	48	38	43	41	40	37	37	37	34	34	30†									
D	32427	N	18	25	23	23	27	24	26	24	21	22	21	22†										
D	32432	N	18	25	21	21†																		
D	32431	N	18	29	22	21	23	21	20†															
D	32428	N	18	32	30	29	30	24	28	27	29	27	28	28	28	25	27	26	27	26	26	26	—	25
D	30676	N	18	23	20	24	25	22	24	22	21	20	20†											
D	30689	N	18	22	18	20	21	20	22	20	20	20	20	20	20	20	17	19	19	18	15	15†		

*B=British Breed, N=Native.
†Died before next weighing.

Table 2.—Body weights of native pigs of equivalent age to those distributed at Okiufa, held at Tropical Pig Breeding Research Centre, Goroka

Ear Tag No.	Sex	Age (weeks)	Body Weight (lbs)
30647	F	39	37
39435	F	39	45
32434	F	39	39
30675	F	39	24*
30685	F	39	49
32436	F	39	47
30688	F	39	46
32426	F	39	43
30687	F	39	45

*This pig was suffering from anaemia at the time of weighting.

improvement of genotype quality be accompanied by some improved standards of husbandry, nutrition and disease control. At the same time it is apparent that the purebred indigenous pig cannot form the basis of an even mildly improved management system, and that some "improved breed" blood must be introduced as soon as any improved system of husbandry is instituted. The matching of genotype with environment will be the most vital aspect of the development of various management systems suitable for the indigenous farmer.

REFERENCE

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THE PRODUCTIVITY OF EXOTIC AND INDIGENOUS PIGS UNDER VILLAGE CONDITIONS—PART 2

ABSTRACT

G. L. MALYNICZ*

A total of 129 *exotic weaner pigs were distributed to village people at a number of centres in the four districts of the Highlands. Mortalities approached* 30 *per cent six months after distribution, with weight gain averaging less than* 100 *grams daily. The implications of these findings for increasing village productivity are briefly discussed.*

INTRODUCTION

IN the first part of this paper (Malynicz 1973) the results of distributing 16 pigs into a typical Highland village were presented. These indicated that pigs under village conditions sustained high mortalities, and that the growth rate of survivors was low. There did not appear to be any association between genotype and either mortality or growth rate, with exotic and indigenous pigs suffering equally high losses.

The present study contains the results of a larger survey into the performance of 129 exotic breed pigs which were distributed to a number of villages throughout the Highlands.

MATERIALS AND METHODS

The normal scheme of distribution for pigs from D.A.S.F. piggeries is as follows. First a Rural Development Officer places an order for stock through his District Livestock Officer, who relays the request to the nearest piggery. Weaner pigs are then sent as soon as they are available to the Extension Centre from which the animals are sold to village people at a subsidized price. In many cases where Extension Centres are inaccessible by road, pigs are flown to their destination. For the pigs used in the survey the normal distribution procedures were followed, with the exception that the pigs were weighed monthly after distribution.

All pigs distributed throughout the survey were either purebreds (Berkshire, Tamworths or Large Blacks) or crosses with the indigenous breed but containing at least three-quarters Exotic blood.

Superimposed on the general distribution survey were two smaller studies conducted at Mount Hagen and Henganofi. At Mount Hagen two groups of pigs matched for litter, sex and body weight were distributed to two different villages, Plymp and Beaprui. The objective was to determine the degree of variation which can occur in the performance of distributed pigs in two adjacent villages.

The second set of observations was carried out to determine whether putting the pigs on a village diet of sweet potato, meat meal and grazing for one month prior to distribution would improve survival and performance. The control group received a normal cereal based ration and was housed intensively on concrete. The pigs in these two treatment groups, which were called "hard" and "control" were distributed through the Henganofi Extension Centre.

RESULTS AND DISCUSSION

The mean monthly liveweights and average daily weight gains of the distributed pigs is shown in *Table* 1. It is apparent that there is considerable variation in the performance of the pigs in terms of weight gain, with pigs at Minj gaining weight at almost nine times the rate of those at Kundiawa. Similar pigs retained at the Goroka piggery which have been fed standard commercial rations gain between 400 and 600 grams daily. This comparison demonstrates that growth under village conditions, even at its optimum is severely depressed. It is considered that the main factors restricting growth are undernutrition of all nutrients with the possible exception of Vitamin A. The comparison between Plymp and Beaprui shows the wide variation that can be found even when very similar pigs are distributed to adjacent villages.

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Table 1.—Mean monthly liveweights of exotic pigs distributed in the Highlands

Location	Number of pigs	MEAN MONTHLY LIVEWEIGHTS (kg)						Average Daily Gains (g)
		1st Month	2nd Month	3rd Month	4th Month	5th Month	6th Month	
Kundiawa	13	16.09	15.82	N.A.	19.23	21.82	N.A.	16
Margarima	21	N.A.	N.A.	N.A.	N.A.	22.73	N.A.	41
Minj	10	15.91	15.77	20.09	24.09	33.41	39.09	140
Pangia	24	N.A.	N.A.	N.A.	22.64	N.A.	N.A.	48
Wapenamanda	21	21.14	25.91	28.86	35.14	38.32	N.A.	126
Plymp	10	18.95	21.50	23.95	26.27	27.04	38.64	125
Beaprui	10	18.77	20.30	19.82	20.22	N.A.	24.00	29

N.A. = Not available.

There does not appear to be any benefit from introducing pigs to a simulated village environment prior to distribution. There was no significant difference in the growth rates of the "hard" and "control" groups of pigs as shown in *Table* 3.

The mortality figures shown in *Table* 2 tend to reflect the growth performance of *Table* 1, with villages in which growth rates were above average having the lowest mortalities and vice versa. Six months after distribution at least one-third of the pigs can be expected to have died. The causes of deaths were not determined but it is felt that malnutrition and parasitic disease would be the main underlying causes. It should be noted that the mortalities sustained by pigs in the present survey are lower than those observed by Harvey (1965) and at Okiufa (Malynicz 1973).

The observations presented in this paper support the findings of Harvey (1965) and those obtained at Okiufa in demonstrating that exotic pigs are unable to express their potential productivity under village environments. Considerable changes in nutrition and management will be required before exotic pigs can be expected to be more productive than their indigenous contemporaries.

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Table 2.—Cumulative mortality of exotic pigs distributed in the Highlands

Location	Number of pigs	CUMULATIVE MORTALITY RATE (per cent)					
		1st Month	2nd Month	3rd Month	4th Month	5th Month	6th Month
Kundiawa	13	0	0	0	0	31	39
Margarima	21	N.A.	N.A.	N.A.	N.A.	N.A.	14
Minj	10	0	0	0	10	20	30
Pangia	24	N.A.	N.A.	N.A.	42	N.A.	N.A.
Wapenamanda	21	0	10	10	19	19	N.A.
Plymp	10	0	0	0	0	0	20
Beaprui	10	0	0	0	0	10	30

N.A. = Not available.

Table 2.—The performance* of pigs fed and manag ed under village conditions before distribution

	Treatment	
	Hard	Control
Initial weight (Kg)	18.27	18.14
Weight at 1st month (Kg)	23.23	22.95
Weight at 2nd month (Kg)	25.82	25.68
Weight at 3rd month (Kg)	33.64	32.05

* The final cumulative mortality after three months for the hard and control groups were 10 and 20 per cent respectively.

GROWTH AND CARCASS MEASUREMENTS OF INDIGENOUS AND EXOTIC PIGS RAISED IN TWO HOUSING SYSTEMS IN PAPUA NEW GUINEA

ABSTRACT

G. L. MALYNICZ*

Ten indigenous and 10 *exotic pigs were housed individually either on dirt lots exposed to the elements or in small concrete floored pens. The dirt lots were unhygienic and infested with nematode parasites. There were significant breed differences for all parameters studied except dressing percentage. Housing system affected weight gain, food conversion ratio, dressing percentage and back fat over the eye muscle. There were no significant breed x housing interactions. Significant differences within breeds between litters were observed for a number of parameters.*

INTRODUCTION

THE normal system of pig husbandry in the Highlands of Papua New Guinea is to allow the pigs free grazing during the day and housing at night (Malynicz 1971). This necessitates fencing food gardens to protect against grazing pigs. It is probable that increasing maintenance requirements of garden fences is a contributory factor leading to the abandonment of food gardens. In some areas Local Government Councils have invoked "pig rules" encouraging the enclosure of pigs rather than gardens. Because this usually restricts grazing, pigs under such conditions perform even less adequately than normal.

There is no published information on the growth and development of indigenous pigs compared to imported breeds. This paper describes an experiment designed to provide basic information on growth and carcass quality in the indigenous pig compared to imported breeds and to assess whether unhygienic conditions markedly affected performance.

MATERIALS AND METHODS

Twenty weaner pigs, consisting of five pairs of indigenous and five pairs of exotic pigs were used in the experiment. The exotic pigs were either Berkshire or Tamworth. Each pair was from a different litter. One animal from each pair was allocated at random to one or other of the housing systems which were designated as "dirt" or "concrete". The "dirt" lots consisted of a muddy fenced area 6 x 1.5 m. Water was provided in one drum and food in another. Shelter was provided in an oil drum from which one end had been removed. The area in which the dirt lots were constructed had been heavily stocked with village pigs which were known to be heavily parasitised. In short, conditions were made as unhygienic as possible.

The "concrete" groups were also housed individually in concrete floored pens, 1.5 x 0.9 m. Food and water were supplied *ad libitum* to both groups. The composition of the rations used is shown in *Table* 1.

Pigs commenced the experiment at weaning at 56 days of age. They were dewormed with Tetramisole* after weaning. The experiment was completed after 100 days when the pigs were sent to the abattoir for slaughter.

The procedures for slaughter and appraisal were essentially those used in South Australia, which is a combination of the Smithfield and Downey methods. The following measurements were taken on the chilled half carcass:—

1. Cold carcass weight, including head.
2. Carcass length from the pubic symphysis to the junction of the first rib with the sternum. The side is then cut through the seventh to eighth rib forward from the sacrum exposing the cut surface of the *Longissimus dorsi*, or "eye muscle".

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* Nilverm granules, Imperial Chemical Industries.

Table 1.—Composition of Rations

	%
Ground Sorghum	80
Protein Concentrate*	20

*The concentrate was produced by Huttmills of Melbourne and gave final allowances in the ration of 0.4% salt, 1,700 I.U. Vit A, 2550 I.U. Vit D3, 12.3 I.U. Vit E and 5.3 I.U. Vit B2 per Kg.

3. The width (A) and depth (B) of the eye muscle was measured.
4. The thickness of back fat over the eye muscle was measured at a point 2.5 cm from the mid-line (C).

The variance between observations was analysed according to Steel and Torrie (1960) and partitioned into breed, housing, breed x housing interaction and within breed litter effects.

RESULTS AND DISCUSSIONS

The results shown in *Table* 2 indicate that the indigenous pig is significantly slower growing, has a lower food consumption, a worse feed conversion ratio, and smaller eye muscle and back fat dimensions at an equivalent slaughter age. The effect on carcass measurements are considered to be largely due to the much smaller carcasses of the indigenous pigs. These results support those of Kemm, Pieterse and Lesch (1967) who, when comparing the primitive Bantu pig of South Africa with the imported Landrace reported similar findings.

The effects of the housing systems were less marked than those due to breed. Weight gain and food conversion ratio were adversely affected, although there was no significant effect on food consumption. The effect was not as large as might have been expected bearing in mind the severity of the "dirt" treatment. Of the carcass measurements dressing percentage was adversely affected although the difference in carcass weight did not quite reach significance ($p<0.1$). The effect on the back fat at (C) was quite marked and may be larger than can be accounted for simply by differences in carcass weight.

Two of the major variables between the housing systems were temperature and spatial density. Temperature was not considered likely to have reduced back fat, since Holmes (1971) found that high temperatures increased back fat. The effect of spatial allocation on back fat has been studied by Heitman *et al.* (1961) and Hughes and Reimer (1967). In neither of these studies did spatial allocation significantly affect back fat.

The effects of different litters was most marked in the exotic pigs where significant differences at the commencement of the experiment were carried through into a number of other parameters including dressing percentage and eye muscle dimensions. A significant litter effect was also observed for indigenous pigs with respect to eye muscle width suggesting the possibility of genetic selection for this trait. As might be expected from the significant litter differences in the exotic breeds the coefficient of variations (x/s) was larger for most of the parameters studied in the exotic breeds.

The results have provided basic data on the growth performance and carcass characteristics of the indigenous pig compared to imported commercial breeds. In addition the effects of unhygienic housing have been studied and shown to account for only a minor part of the variance for each parameter with the exception of back fat. It appears therefore that in the short term, performance will not be adversely affected by poor housing conditions. Long term effects, particularly due to chronic infection with helminth parasites such as *Stephanurus dentatus*, could well affect performance particularly of breeding animals.

ACKNOWLEDGEMENTS

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Table 2.—The effect of housing on growth and carcass measurements in indigenous and exotic pigs*

BREED	BRITISH		NEW GUINEA		SIGNIFICANCE OF EFECTS				
Housing	Dirt	Concrete	Dirt	Concrete	Breed	Housing	Breed X Housing	Litter (N)	Litter (B)
N.	5	5	4	5					
Initial weight (kg)	13.91 4.27	13.18 2.50	8.64 2.20	7.73 0.72	0.001	N.S.	N.S.	N.S.	0.01
Daily gain (g)	404 78	495 89	185 30	236 71	0.001	0.05	N.S.	N.S.	N.S.
Daily food consumption (kg)	1.60 0.15	1.63 0.20	1.06 0.08	0.95 0.33	0.01	N.S.	N.S.	N.S.	N.S.
Food conversion ratio	4.23 1.10	3.34 0.41	6.04 0.83	4.05 0.85	0.01	0.05	N.S.	N.S.	N.S.
Dressing percentage	73.60 5.41	74.2 5.22	72.8 2.86	75.00 1.58	N.S.	0.05	N.S.	N.S.	0.001
Carcass length (cm)	67.81 5.09	68.81 6.41	49.78 2.52	50.68 2.98	—	—	—	—	—
Eye muscle (A) (cm)	6.17 1.80	6.53 1.53	4.99 1.02	5.01 0.64	0.001	N.S.	N.S.	0.01	0.001
Eye muscle (B) (cm)	3.580 0.978	3.780 0.691	2.960 0.321	3.240 0.416	0.01	N.S.	N.S.	N.S.	0.01
Back Fat at (C) (cm)	1.566 0.355	2.028 0.310	1.248 0.346	1.676 0.077	0.05	0.01	N.S.	N.S.	N.S.
Carcass weight (kg)	40.73 10.96	45.55 11.18	19.91 4.30	23.65 3.57	0.001	N.S.	N.S.	N.S.	0.01

*Mean ± Standard Deviation

EFFECT OF SEEDNUT TRIMMING ON THE GERMINATION AND GROWTH OF COCONUTS

E. T. KENMAN*

ABSTRACT

In a trial to compare the growth rate of variously trimmed and positioned seednuts of coconuts, six different treatments were used.

The seednuts were positioned horizontally and vertically, and various sections of exocarp and mesocarp were trimmed away.

There were significant differences in both the trimming and positioning treatments with horizontal placement being superior to vertical and partial removal of exocarp showing an improvement in plant germination and growth.

INTRODUCTION

WITH the increasing use of polythene bags for coconut nursery planting in the British Solomons there was a need to revise planting methods. Nuts planted in the usual (horizontal) position were too big for the standard size poly-bags used in oil palm nurseries which are about 10 inches in diameter.

EXPERIMENTAL METHODS AND RESULTS

Malayan Tall seednuts were hand harvested to ensure uniformity of maturity. These were placed in eight replicates of six treatments with 30 nuts for each plot in the pre-nursery, from which 20 seedlings were selected for each plot in the nursery proper.

In the pre-nursery the nuts were covered lightly with coconut fronds to improve moisture retention, as is the normal practice in the British Solomons.

The nursery soil was a deep well-drained clay loam rich in humus and relying on rainfall for moisture throughout the experiment (November, 1968 to July, 1969). Positioning and trimming treatments were as follows: (see also *Figure* 1).

Horizontal

(*a*) Whole nut, horizontal.

(*b*) Exocarp (thin outer layer) removed from the lower half, horizontal.

(*c*) As for (*b*) with mesocarp (fibrous bulk of husk) also removed from lower half exposing the shell.

(*d*) A portion of the exocarp and one to two cm thickness of the mesocarp removed from over the germ pore; lower side untrimmed; horizontal.

Vertical

(*e*) Untrimmed, vertical.

(*f*) Mesocarp removed from the lower half, vertical.

A dry day is defined as one with less than 0.1 inch of rainfall, which would be less than half the normal evapo-transpiration occurring in Yandina conditions. A dry period (*Table* 1) is a series of such days, over which there would be appreciable drying out of the soil.

Germination was recorded at two week intervals from seednut harvest to eight weeks and is shown as percentages in *Table* 2.

Only horizontal nuts with some husk removed from over the germ pore (Treatment D) germinated faster than Treatment (A). This effect would have been due at least in part to the shoot being visible earlier in Treatment (D).

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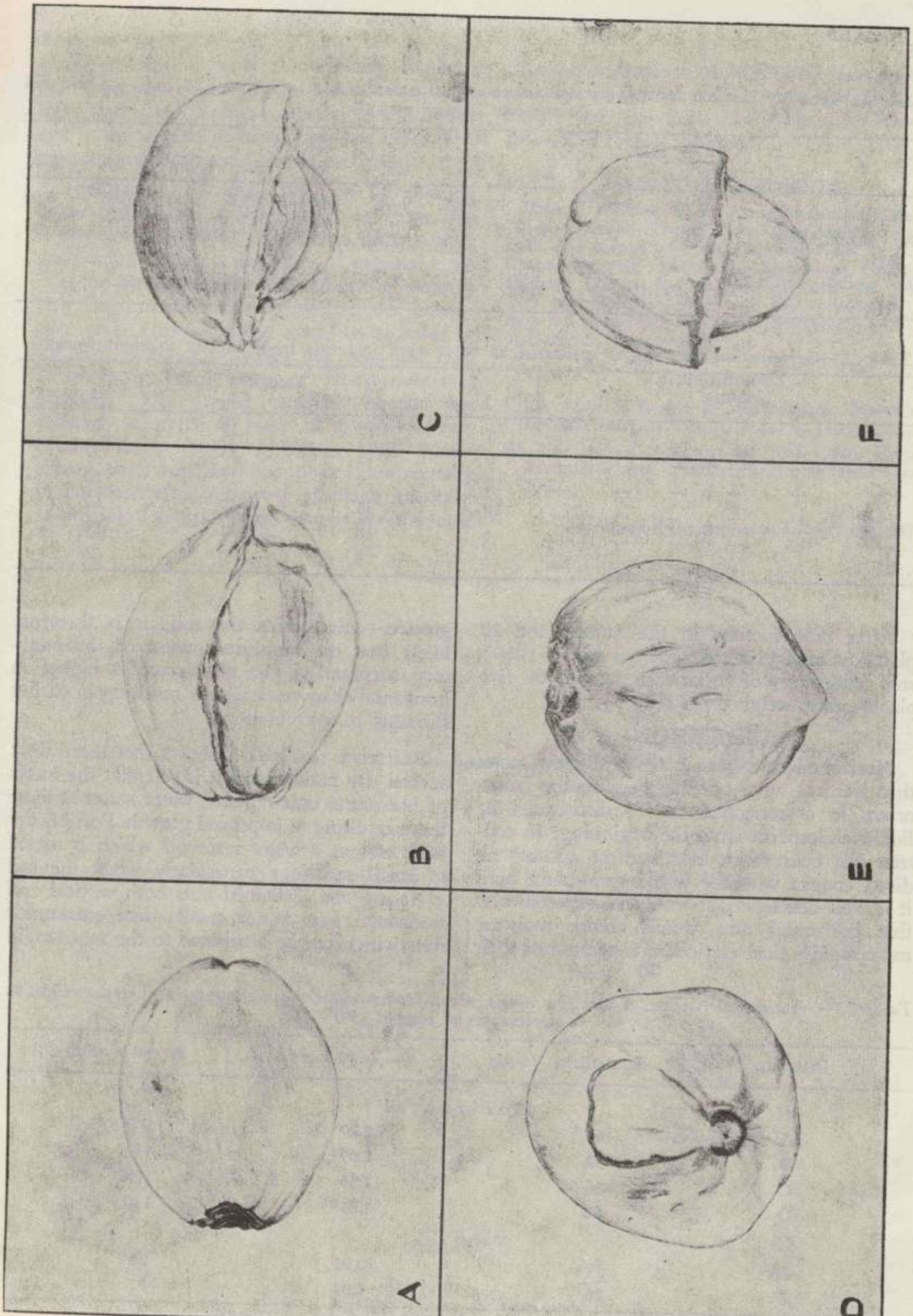

Figure 1.—Positioning and trimming treatments: see text for details

Table 1.—Monthly rainfall and dry periods in which not more than 0.10 inches (2.5 mm) of rain fell in any one 24-hour period

	1968		1969							
	Nov.	Dec.	Jan.	Feb.	Mar.	Apl	May	June	July	TOTAL
Rainfall (inches)	6.23	7.29	12.36	7.92	9.61	14.04	2.37	4.51	6.62	70.95
Dry period over 7 days	2	0	0	0	0	0	1	1	1	5
Dry period over 5-7 days	0	1	1	1	1	0	2	0	0	6

Table 2.—Germination percentages measured at tw o week intervals from harvest to eight weeks

Treatment	Weeks from Harvest			
	2	4	6	8
A	1	17	33	47
B	0	13	25	32
C	0	9	17	26
D	19	35	49	62
E	1	10	21	39
F	1	9	14	26

After nine months in the nursery the 20 plants in each plot were cut out (July, 1969) and fresh tops of a random sample of five plants were weighed (*Table* 3).

DISCUSSION

Horizontal nuts germinated and grew faster than vertical nuts, possibly because the haustorium in a horizontal nut is surrounded by liquid endosperm from the beginning. In contrast the haustorium in a vertical nut has no direct contact with the liquid endosperm until it is well developed. It would be expected also that horizontal nuts would absorb moisture more rapidly than vertical nuts because of their greater contact with the soil. It is therefore likely that the moisture content of the mesocarp surrounding the germ pore is higher in horizontal than vertical nuts resulting in earlier stimulus to germination.

Reference to *Table* 1 shows that there were several dry periods and it is felt that the husks of horizontal nuts retained water better at these times resulting in improved growth. Possibly the husk acts as a water reservoir which is useful to small seedlings particularly when the soil is drying out. Trimmed nuts both vertical and horizontal gave better results than untrimmed nuts which can be attributed to the more rapid

Table 3.—Germination percentage at eight weeks, mean fresh weight at nine months and fresh weight as a percentage of control (A)

Treatments	Germination at 8 weeks	Weight in kg	Per cent of weight of A
		Horizontal	
A	47	1.29	100
B	32	1.69*	131
C	26	1.55	120
D	62	1.81*	140
		Vertical	
E	39	0.92	70
F	26	1.05	81

Least Sig. Diff (P=0.05) 0.39

*Significantly different from A at P=0.05

water absorption with the exocarp removed and freer movement of the roots through the husk to the soil. Vertical nuts have a disadvantage in the greater distance from the germ pore to point of emergence from the husk.

Treatments (D) and (B) gave significantly better results and a combination of these two is recommended. This would be a fairly simple procedure; cutting a thin slice of exocarp from over the germ pore (D) and removal of exocarp only from underneath to facilitate root emergence (B). This treatment would be of value in nurseries without polybags but does not help to overcome the problem of fitting nuts into polybags. The results establish clearly that removal of parts of husk is generally beneficial. Further trials (J.C.R.S. 1969) have shown that nuts may be placed horizontally in polybags after removing as much mesocarp as possible from the distal end. It is considered that the advantages of horizontal nuts demonstrated in this trial and by other workers (e.g., C.I.B. 1962) indicate the value of horizontal placement even in polybags.

ACKNOWLEDGEMENTS

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THE ESTABLISHMENT OF EXOTIC FRESHWATER AQUARIUM FISH IN PAPUA NEW GUINEA

G. J. WEST*

ABSTRACT

Two species of exotic freshwater tropical aquarium fish have been discovered in natural waters in the Port Moresby area. These are the Guppy, Lebistes reticulatus *(Peters), and the Three-spot Gourami,* Trichogaster trichopterus trichopterus *(Pallas). They may have an adverse effect on native fish, because of ecological disruptions, or introduction of disease. The natural waters of Papua New Guinea provide suitable conditions for the survival of escaped tropical aquarium fish; continued importation of these fish increases the risk of new species becoming established. An alternative to importing aquarium fish is to use native freshwater fish, of which there are over* 100 *species suitable for aquaria. If native fish are used, it would be desirable to restrict their movement to areas in which they occur naturally.*

WHEN exotic aquarium fish are imported it is almost inevitable that some will escape accidentally, or be deliberately released into natural waters. The problem is most acute in tropical countries, where there are suitable natural conditions for the establishment of escaped tropical aquarium fish which constitute the bulk of the aquarium trade.

An analysis of import data shows that six species account for nearly half the total number of individual fish ordered (Filewood pers. comm. 1972).

The species of fish which are permitted into Papua New Guinea is based on recommendations made to the Australian Commonwealth-State Fisheries Conference. These recommendations are, however, based primarily on Australian conditions, where it is considered unlikely that escaped aquarium fish could survive in natural waters, particularly in the colder southern states (Munro 1960). However, this does not apply to the lowland waters of Papua New Guinea. Proof of this is the establishment in natural waters around Port Moresby of the Guppy, *Lebistes reticulatus* (Peters), and the Three-spot Gourami *Trichogaster trichopterus trichopterus* (Pallas).

Accidental Introductions into Natural Waters

The Guppy was first reported in drains in the Port Moresby suburb of Boroko in 1967, and has since been found in waters draining into the nearby Waigani Swamp, which forms part of the Laloki River system.

This species can be expected to spread, as it has in Indonesia, where it competes for food with more valuable native fish (Schuster 1950). The Guppy grows to a size of only about 4 cm, and is not used for food.

The Three-spot Gourami was first reported in the Laloki River in 1970 (Moore pers. comm. 1970). In the shallow backwaters where it is commonly found, it is the dominant species, exceeding in numbers both native fish species and the deliberately introduced *Tilapia mossambica* Peters, and the Snake-skinned Gourami, *Trichogaster pectoralis* (Regan).

Problems Created by Escaped Aquarium Fish

Concern over the occurrence of aquarium fish in natural waters is based on the inevitable ecological disruptions which ensue, and the risk of introducing diseases.

On a practical level, the basis for concern over the ecological effects of aquarium fish in natural waters "is essentially one of competition with native species for food and space backed by predation on eggs, fry and adults" (Munro 1960). Even after very careful research into the possible effects of an aquarium fish becoming established in natural waters, it is impossible in many instances to guarantee that harmful effects will not occur (Schultze-Westrum 1970). Consequently, drawing up lists of aquarium fish approved for import offers

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no protection for the freshwater fish fauna, unless there is no possibility of the aquarium fish becoming established in the wild.

There is considerable risk of introducing diseases harmful to native fish populations, to useful introduced species of fish, or even to man, through the occurrence of aquarium fish in natural waters. International traffic in live freshwater fish and ova has aggravated the spread of diseases, among which the most prevalent are whirling disease, swim bladder inflammation, and furunculosis. It has been recommended that international controls be initiated applying first to cultivated fish, such as trout and salmon, and then to ornamental fish (Australian Fisheries 1972).

In Papua New Guinea there are strict quarantine conditions which must be satisfied before cultivated fish may be imported. This is to prevent diseases harmful to man, such as clonorchiasis, from being introduced. However, ensuring that imported aquarium fish are free from disease harmful to other fish is much more difficult: diagnostic methods are often very sophisticated, the required staff need to be highly trained, and the number of fish species and individuals involved is very large. The only practical solution may be to impose a complete ban on the importation of aquarium fish, as has been done recently in Fiji (Spottiswoode, pers. comm. 1972).

Native Aquarium Fish

An alternative to importing aquarium fish, which eliminates many of the problems associated with exotic fish introductions, is to use suitable species of native fish, or species of introduced fish which are already established in natural waters. There are over 100 species of freshwater fish native to Papua New Guinea which are suitable for aquaria. Approximately fourteen families of fish found in estuarine and fresh waters in Papua New Guinea are common to the world-wide aquarium trade. These are listed in *Table* 1.

Apart from the two species of aquarium fish present in freshwaters around Port Moresby, there are four species of deliberately introduced fish established in Papua New Guinea. These are the following:—

Cyprinus carpio Linnaeus—Common carp

Gambusia affinis (Baird & Girard)—Mosquito fish

Table 1.—Families of native fish used in aquaria

Family	Common Name
Anguillidae	Eels
Chandidae	Glassy-perchlets
Eleotridae	Gudgeons
Gobidae	Gobies
Melanotaenidae	Rainbowfish
Monodactylidae	Silver batfish
Mugilidae	Mullet
Periophthalmidae	Mud-skippers
Plotosidae	Catfish-eels
Scatophagidae	Scats
Syngnathidae	Pipefishes
Telmatherinidae	Sailfin silversides
Theraponidae	Therapon perch
Toxotidae	Archer fish

Tilapia mossambica (Peters)—Tilapia

Trichogaster pectoralis (Regan)—Snake-skinned Gourami

If any of these native or established introduced fish are to be used in aquaria, it is essential that the particular species be present in natural waters in the area in which the aquarium is situated. There are several reasons for this:—

1. With regard to introduced fish, it is not desirable to increase their distribution, because the effect of these exotic fish is not yet understood, and there is concern that their spread could harm valuable native fisheries.
2. With regard to native fish, there are very definite differences in the zoogeographical distribution of various species. The zoogeography of native fish is, however, not completely known and transplants of these fish are not desirable from a scientific point of view. More importantly, transplants are not desirable ecologically, as in some situations transplants of native fish into different drainage basins may have effects comparable with those resulting from the introduction of exotic species (Lachner *et al.* 1970).

It has been conservatively estimated that approximately 12,000 aquarium fish are imported annually into Papua New Guinea (Filewood, pers. comm. 1972). Use of native fish to replace these imports could be the basis of a small local industry.

ACKNOWLEDGEMENTS

I am indebted to the biologists at Kanudi Fisheries Research Station for their helpful advice in the preparation of this paper.

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SOME ASPECTS OF INSECTICIDE APPLICATION IN MALARIA CONTROL PROGRAMMES OTHER THAN THE EFFECT ON THE INSECT VECTORS

T. V. BOURKE*

ABSTRACT

Reported side effects arising from the application of DDT emulsion or suspension to buildings to control the anopheline insect vectors of malaria in Papua New Guinea are outlined.

Reports of effects of spraying on the deterioration of sak sak roof thatch from a resultant build up in numbers of larvae of the pyralid moth Herculia nigrivitta *Walk. are rather confusing, although from evidence presented it would appear that* H. nigrivitta *numbers have increased as a result of spraying. This increase could be due to the effects of DDT on non-specific predators which are found in association with* H. nigrivitta *larvae and on tachinid parasites. No satisfactory control measures for* H. nigrivitta *have as yet been devised. Further work is required to obtain information on the pest status, bionomics and habits of* H. nigrivitta, *and on the effects of spraying on* H. nigrivitta *populations and on roofing thatch.*

Reported increases in numbers of the mealybug Planococcus dioscoreae *Williams on yam roots in storage houses in the Maprik Subdistrict in 1959 following malaria spraying were investigated and found not to be associated with the spraying. There was little difference between the mealybug infestation in sprayed and unsprayed storage houses, and it was concluded that the main reason for the outbreak was the low density of predatory scymnine coccinellids which could have resulted from a temporary change in the micro-climate or some other cause unrelated to antimalarial spraying.*

The reported build up of bed bug (Cimex hemipterus *F.*) *populations in sprayed houses would appear to be true, but further more detailed work is required. The reasons for the build up are by no means clear, but resistance to DDT is one possibility.*

Reported build ups in Pediculus humanus humanus *L. numbers were not substantiated.*

DDT residues and possible contamination arising from its use are broadly discussed. No information on the effects of DDT on humans and wildlife in Papua New Guinea as a result of malaria control spraying is available. There is no doubt that direct contamination of water supplies and creeks must occur, even though every possible precaution is taken.

Replacement of DDT by alternate materials is discussed, but rejected on the grounds that DDT is the safest, cheapest and most effective insecticide for indoor residual spraying against malaria vectors. Alternative materials, and there are only two available, are more expensive, less residual in their effects and are not as safe to use as is DDT.

INTRODUCTION

REPEATED application of DDT to native material dwellings to control the anopheline insect vectors of malaria has led to some substantiated and unsubstantiated side effects being reported. Such insects as the sak sak leaf eating pyralid *Herculia nigrivitta* Walk., bed bugs (*Cimex hemipterus* F.), body lice (*Pediculus humanus humanus* L.) and the coccid *Planococcus dioscoreae* Williams, which inhabits yam roots, have been reported as reaching pest proportions following prolonged use of DDT.

Department of Agriculture, Stock and Fisheries' entomologists have looked at some of these problems. Messrs A. Catley and A. G. Basson and Dr E. Hassan have investigated various aspects of *Herculia nigrivitta*; Dr J. J. H. Szent-Ivany was intimately associated with a study on the effect of DDT and dieldrin malaria spraying on the incidence of *Planococcus dioscoreae* on stored yams in the Maprik Subdistrict (East Sepik District) in 1959; and T. V. Bourke and Dr C. S. Li investigated the *Cimex hemipterus* situation.

The effects of possible exposure of humans and animals to residues and contamination of food and water supplies as a result of malaria control spraying are discussed, as are possible toxicological hazards of DDT and possible alternate insecticides to spray team personnel.

HERCULIA NIGRIVITTA

In October 1962, a report was received from the District Commissioner, Sepik District to the effect that: "according to large sections of the community, mainly the Maprik, Kalabu and Wingei areas, when a (native materials) house is sprayed (with DDT) the native morata (sak sak) roof no longer has the life that it had previously".

It appeared that the deterioration of both new and old sak sak roofs had accelerated since malaria control spraying commenced in the area, and whereas before spraying a roof had been expected to last from three to five years, it now lasted only one to two years. This accelerated deterioration was put down to population increase of a caterpillar (subsequently identified by the Commonwealth Institute of Entomology as *Herculia nigrivitta*) resulting from the spraying campaign.

Mr A. P. Dodd, former Director of the Biological Control Branch of the Department of Lands, Queensland, who was in the area on a private trip during October 1962, inspected the problem. He concluded that *H. nigrivitta* larvae were certainly responsible for the damage recorded and suggested that spraying could be upsetting the naturally occurring parasites and predators, thus causing a build up of *H. nigrivitta* with a consequent increase in damage.

Catley (1962) carried out further investigations and reported that whilst little was known about the insect's biology, it did appear that eggs were laid on the dried sago leaf thatching and that the young larvae fed on the dried leaves, preferring to hide either in the curled over leaves or between layers of thatching. Leaves were bound together with silk to form a protective shelter for the larvae which, when fully fed, pupated at the feeding site.

Larvae did not attack green leaves and even recently browned ones, about six weeks after cutting, were free from attack. Leaves older than six weeks were rapidly infested. Very old thatching did not appear to be attractive to larvae and was not eaten unless the number of larvae were such that competition forced them to accept the less palatable thatching. Feeding was continuous throughout the day, but increased at night. Large quantities of dark brown, dried frass were continually voided by the larvae as they fed and was most noticeable on the floors of infested houses. The adults, small blackish-brown moths, were also to be found hiding under the thatching during the day.

Catley did not observe any predators actually attacking larvae, but concluded that non specific predators such as ants (*Technomyrmex* sp., *Iridomyrmex* sp. and other unidentified species), cockroaches, lacewing (Chrysopidae) larvae, pseudo-scorpions, spiders and lizards found in association with *H. nigrivitta* larvae, probably exercised considerable control under natural conditions.

Unfortunately all are very susceptible to chlorinated hydrocarbon insecticides and it appeared that the DDT residues on the walls

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of the houses had been instrumental in reducing their numbers to a very low level. In fact in many of the sprayed houses it was difficult to find signs of any life other than *H. nigrivitta* larvae, whereas in unsprayed houses the inside walls were generally covered with a mat of spider webs and *Technomyrmex* runways.

Tachinid parasites (? *Sturmia* sp. or ? *Winthemia* sp.) and "stung" *H. nigrivitta* larvae bearing tachinid eggs on the head or thorax were commonly seen in both sprayed and unsprayed houses, with the incidence appearing to be greater in sprayed houses.

There was no indication that *H. nigrivitta* larvae were resistant to DDT, but rather that their feeding habits did not bring them into contact with the insecticide. DDT, when used as a wettable powder, is not absorbed into the leaf tissue and is therefore located only on the surface of the thatching on the inside of the walls. As mentioned previously, *H. nigrivitta* larvae feed either within the curled leaves or between layers of thatching and not on the DDT treated surfaces. Once the leaf is eaten away to the DDT treated side, feeding ceases at that site and they begin to feed at another site.

Catley also stated that another factor which could influence control of *H. nigrivitta* by the DDT spray was smoke from fires lit inside the houses. The deposits of DDT on the walls of treated houses are soon covered by deposits from the smoke and become ineffective.

In contrast, Hassan (personal communication) was of the opinion that in the Northern District at least, smoke fumes protect thatching from *H. nigrivitta* damage. This observation supports those of Moorhouse (1964) who found that in Malaysia damage was most severe on outside porches, eaves and other unenclosed places, moderately severe in smoke-free living rooms and was minimal in kitchens where open fires were used.

Catley suggested two methods of control—fumigation of sprayed houses with lindane smoke bombs when spraying was carried out and the use of volatile additives such as dichlorvos in the standard DDT spray.

Basson (1963) investigated the problem further and also experimented with lindane smoke bombs. He confirmed Catley's observations on the life history and behaviour of *H. nigrivitta* and also observed that some unsprayed houses in the Apua hamlet of Maprik Village which were being used for mosquito collection purposes were as severely damaged as sprayed houses. Basson concluded that in areas where prolonged spraying with DDT had been carried out, the *H. nigrivitta* population had built up to such level that new, unsprayed houses were at risk of infestation soon after they were erected.

Experimental use of lindane smoke generators did not result in death of larvae and Basson suggested that the only way to protect newly built houses was to treat them with a persistent insecticide shortly after erection or to include treatment during the building of the house.

Jeffery, in an unpublished report to the Director, Department of Public Health dated 1st November, 1968, reported that BHC when applied at the rate of 0.5 g/m^2 to experimental sak sak roofs persisted for up to 12 weeks with a high kill rate, even when mixed with DDT (2 g/m^2). Dichlorvos, when applied to experimental sak sak roofs as a 0.005 per cent spray (no actual rate of active ingredient application given) gave the same results as the BHC treatment.

In Malaysia, dieldrin applied at the rate of 400 mg/m^2 to sak sak reduced damage but did not provide a satisfactory answer to the problem (Moorhouse 1964). The toxicological hazards associated with the use and residues of dieldrin would preclude its use under Papua New Guinea conditions.

H. nigrivitta has also been investigated in Malaysia (Cheng 1963, Moorhouse 1964), but the results of these two investigations appear to conflict in some respects. Larvae collected by Moorhouse in Selangor were found to be resistant to DDT (but moderately susceptible to both BHC and dieldrin), whilst those collected in Sabah by Cheng escaped the DDT by avoiding DDT treated sak sak surfaces. The Sabah larvae refused to eat DDT treated material, but those from Selangor readily ate DDT treated sak sak.

The only parasite recorded by both Cheng and Moorhouse was the hymenopterous pupal parasite *Antrocephalus* sp. (Chacididae). This parasite has not been recorded from Papua New Guinea.

From field observations Cheng (1963) concluded that most of the unsprayed houses whilst they also had rotting roofs, as did the sprayed ones, had more *H. nigrivitta* larvae present in their sak sak roofs. Moorhouse (1964) was fairly definite in that his field observations confirmed reports that sprayed sak sak roofs were being rapidly destroyed by *H. nigrivitta* larvae.

Further work is being conducted by the Departments of Public Health and Agriculture, Stock and Fisheries in Papua New Guinea to obtain information on the pest status, bionomics and habits of *H. nigrivitta*, and of the effects of spraying with DDT on *H. nigrivitta* populations and on roofing materials (mainly sak sak).

PLANOCOCCUS DIOSCOREAE

In 1959, there were reports from the Maprik Subdistrict of a population build up of a mealybug (subsequently described by D. J. Williams (1960) as a new species, *Planococcus dioscoreae*) on yam roots in storage houses as a result of spraying with DDT and dieldrin for malarial mosquito control. Dr Szent-Ivany visited the area in June 1959 to study the problem, as officers of the malaria control team were concerned that the outbreak in the yam houses could have resulted from spraying the walls of the houses with DDT and dieldrin, thus selectively killing the natural enemies of the mealybug without affecting the mealybug.

Investigations (Szent-Ivany 1959) showed, however, that there was little difference between the mealybug infestation in sprayed and unsprayed storage houses, and it was concluded that the main reason for the outbreak was the low density of predatory scymnine coccinellids, which could have resulted from a temporary change in the micro-climate or some other cause unrelated to anti-malarial spraying.

OTHER INSECTS

Prior to 1970, reports were received from time to time of the stimulation both of bed bugs (*Cimex hemipterus* F.) and of body lice (*Pediculus humanus humanus* L.) in sprayed houses. In 1970, the opportunity was taken to have a preliminary look at DDT resistance in strains of *C. hemipterus* collected from Maprik (East Sepik District) and Gurakor (Morobe District). The bugs at Maprik had been exposed to at least 25 DDT sprayings (at six-monthly intervals), whilst those at Gurakor had nil exposure. Samples of bugs were forwarded from both localities and cultured in the laboratory at Popondetta. For resistance testing, replete adult bugs (they had been fed 24 hours beforehand) were exposed to DDT treated filter papers which were placed in stoppered 4 x 1 inch glass livestock tubes. The filter papers were positioned in such a way that they formed the inner walls of the tubes. Results of the trial are shown in *Table* 1.

There is certainly some indication that DDT resistance was present in the Maprik sample.

Table 1.—Mortality of *C. hemipterus* adults exposed to treated DDT papers

Bugs*	Treatment—DDT per cent	Mortality (per cent) after	
		24 hours	48 hours
Maprik	1.0	—	25
(+25 treatments)	2.5	33.3	75
	5.0	33.3	75
	7.5	33.3	83.3
	10.0	25.0	100
Gurakor	1.0	41.7	66.7
(nil-exposure)	2.5	41.7	75.0
	5.0	83.3	100
	7.5	83.3	100
	10.0	75.0	100

*Twelve bugs used per treatment.

In April 1970, a further trial was commenced to follow the effects of spraying versus no spraying on numbers of *C. hemipterus*. Two villages—Aluki and Apo—in the Morobe District were selected and bed bugs counted in 10 randomly selected houses in each village. The houses in Aluki village were then sprayed with DDT (2 gm/m^2) by one of the malaria spray teams operating in the District, whilst the other village was left unsprayed. Prior to this sampling and spraying, neither village had been sprayed as the villages were in an area which had not then been included in Papua New Guinea's Malaria Control Programme. In theory, it was hoped that both villages would be sampled for *C. hemipterus* in the same randomly selected houses one to two days before spraying and then at one, four, eight, 16 and 24 weeks after spraying, and that the houses in Aluki village would be sprayed every six months with DDT. Unfortunately, Aluki was sprayed with a DDT/malathion mixture in October 1970 and again in May 1971. However the results of the trials are shown in *Table* 2.

From the table it can be seen that spraying did lead to a build up in *C. hemipterus* numbers, but the reasons for this are by no means clear.

This trial should be repeated under more stringently controlled conditions.

To overcome the problem of build up of *C. hemipterus* following DDT spraying, Malaria Services added malathion to the spray mixture at the rate of 0.2 g/m^2.

As *Pediculus humanus humanus* live in such a well protected habitat, the possibility of any population build up as a result of spraying with DDT must be remote. Reported build ups could not be substantiated.

MAMMALS, EXCLUDING MAN

Periodical reports have been received of deaths of cats following prolonged spraying with DDT during malaria control programmes with a supposedly resultant increase in numbers of rats. There may be some truth in this as cats have been seen to devour cockroaches, beetles and other insects, spiders and geckoes which were obviously suffering from DDT poisoning.

Table 2.—**Numbers of *Cimex hemipterus* in 10 randomly selected, fixed sampling houses in a sprayed and an unsprayed village**

Date	Village	
	Aluki (sprayed)	Apo (unsprayed)
14.4.1970	20*	
22.4.1970	0	
30.4.1970	0	
14.5.1970	0	
14.6.1970	0	
19.8.1970	0	
14-15.10.1970	0†	0
28.10.1970	0	0
24.11.1970	0	0
21.12.1970	0	0
23.2.1971	13.3	0
20-21.4.1971	25.6‡	2
14.5.1971	1.4	0
7.6.1971	0	0
7.7.1971	0	0
6.9.1971	1.4	0
5.11.1971	56.3§	0
14.12.1971	44.4	0
15.2.1972	16.7	0

*Village sprayed on 15th April, 1970 with DDT.
†Village sprayed on 21st October, 1970 with DDT/malathion.
‡Village sprayed on 6th May, 1971 with DDT/malathion.
§Village sprayed on 15th November, 1971 with DDT/malathion.

This continuous ingestion of DDT contaminated food must result in an increase in residues within the cats, but it remains to be proved whether it leads to a level whereby a cumulative "acute" level is reached. Ingestion of DDT could also result from the cats rubbing against the treated surfaces and then licking DDT from their fur.

RESIDUES AND CONTAMINATION

Over the past decade pesticide residues have received a lot of attention from legislators, government agencies, and scientific and extension workers. The use of cyclodiene and other hydrocarbon insecticides on livestock in Australia has been banned, with the exception of the permitted limited use of DDT for the control of buffalo fly (*Haematobia exigua* (de Meij.)) in Queensland, as a result of the occurrence of insecticide residues in meat and meat products from treated animals. Residues in milk and dairy produce have arisen from the application of the same group of insecticides to pastures and forage crops in Australia, and their use on pastures has either been banned (cyclodienes) or drastically reduced (DDT, lindane).

Where DDT is currently employed in Australia it is far cheaper than any alternative insecticides that would be acceptable. Alternatives which are available are generally less persistent and thus require more frequent applications and they are often more toxic to man (Australian Academy of Science 1972). Usually little information is available on the long term effects—residues, contamination, etc. —of alternatives. DDT and two of its chief metabolites DDE and TDE* are lipoid soluble and tend to accumulate in body fat, even in the body fat of people without occupational exposure to DDT. It appears that equilibrium is reached between the intake of DDT and the excretion of the sum of its metabolites in approximately one year, if the amount ingested remains constant (Hayes *et al.* 1958). At low dose levels metabolism to the less toxic DDE appears to be quantitively greater.

* The chemical nomenclature for DDT and its metabolites is:

DDT—1, 1, 1-trichloro-2, 2-di-(4-chlorophenyl) ethane.

DDE—1, 1-dichloro-2, 2-di-(4-chlorophenyl) ethylene.

TDE—1, 1-dichloro-2, 2-di-(4-chlorophenyl) ethane.

The concentration of DDT in adipose tissue of humans in various Australian States over varying periods between 1965 and 1971 inclusive are given in Appendix 2 of the Australian Academy of Science's report (1972).

Elsewhere overseas, Canada, West Germany, Japan, Netherlands, New Zealand and the United States of America have drastically restricted and/or partially banned the use of DDT. The West German Bundestag recently passed an act forbidding the manufacture, import, export, marketing or purchasing of DDT within that country.

The position in Papua New Guinea and most other developing countries where malaria causes a high morbidity and mortality in most population groups is that DDT is the only material which has the desired residual effect and exhibits a low toxicity to the applicators and general public. It is also the cheapest and most effective insecticide available for controlling this disease.

The effect of DDT on humans and wildlife as a result of exposure to residues arising from malaria control spraying has received little attention in Papua New Guinea. The contamination of food and water supplies has not, to my knowledge, received any attention in Papua New Guinea. Both indirect and direct contamination of water supplies and creeks must occur, even though every possible precaution is taken. Keenleyside (1962), Rudd (1964) and Frith (1965) have discussed the direct and indirect effects on fish of DDT contamination and residues.

TOXICOLOGICAL HAZARDS

DDT is looked upon as being a relatively safe insecticide, having oral and dermal LD_{50} of 113-118 and 2500 mg/kg body weight (in rats) respectively (Martin 1968). Hayes (1971) summarizes the safety record of DDT (in part only) as follows: "The safety record of DDT for man is truly remarkable—several hundred thousand metric tons per year have been used for agriculture, forestry, public health and other purposes. People have been exposed in almost every way conceivable. For typhus control, the entire population of villages and large cities have had the 10 per cent powder blown into their clothing as they wore it. For malaria control, millions of men, women and children have had the interior walls of their homes sprayed year after year at the rate of

2 g/m². For food protection, such a variety of plants and animals eaten by people have been treated that, apparently without exception, every person sampled in recent years in Europe, Asia, Africa, Australia and the Americas contains a trace of DDT in his blood and in every tissue. Some of those who manufacture, formulate or apply DDT have had no other work for over 20 years and all of them have greater exposure than the general population of their countries. Yet, in spite of the prolonged exposure of the entire population of the world and the heavy occupational exposure of a substantial number, the only confirmed cases of poisoning by DDT have been the result of massive accidental or suicidal ingestion," (Hayes 1971).

DDT in solution can be absorbed through the skin. A single ingestion of 10 mg/kg produced illness in some but not all subjects. Convulsions have occurred when the dosage level was 16 mg/kg or greater. However, dosages as high as 285 mg/kg have been taken without fatal results (Hayes 1955).

To my knowledge no fatalities attributable to DDT have been recorded from Papua New Guinea.

Extensive screening trials seeking alternative insecticides for indoor residual spraying against malaria vectors have been carried out by various laboratories as a part of the W.H.O. Programme for Testing and Evaluating New Insecticides (W.H.O. 1967, Wright 1971, Wright *et al.* 1969). Out of some 1,300 or so compounds which have been examined only six—malathion, propoxur, fenitrothion, dichlorvos, Mobam (R) and Landrin (R)—have shown promise as residual adulticides against malaria vectors, although the period of residual activity of each is less than that of DDT (W.H.O. 1967). The substitution of any of these materials, if they were proved safe to use under field conditions, would substantially increase the cost of a malaria control programme. Factors contributing to this cost increase would be an increase in the price of the compound *per se*, the increased frequency of treatment, the need for monitoring of spraymen to detect excessive exposure, and closer supervision and training of field teams.

Only malathion has so far passed all the criteria necessary before a material is recommended for field use. Malathion, as has been mentioned earlier, has been added to the DDT mixture being used in Papua New Guinea's malaria control programme to control bed bugs. Monitoring of whole blood cholinesterase levels was carried out at six-monthly intervals by the Department of Public Health. Results showed no deviation from normal amongst malaria staff using malathion over a period of 12 to 18 months. Malathion, an organophosphorus insecticide with oral and dermal LD_{50} figures of 1400-1900 and 4000 mg/kg respectively is looked upon as being a relatively safe insecticide (Ben-Dyke *et al.* 1970). However extensive field use of trichlorphon, another organophosphorus insecticide with LD_{50} figures of 650 and 2800 mg/kg respectively, would suggest that monitoring of spraymen using supposedly "safe" organophosphorus insecticides under semi-enclosed or enclosed conditions must be both regular and thorough (Bourke *et al.* 1971).

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NATURAL ENEMIES OF *AXIAGASTUS CAMBELLI* DISTANT (HEMIPTERA: PENTATOMIDAE) ON THE GAZELLE PENINSULA, NEW BRITAIN

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ABSTRACT

The coconut spathe bug, Axiagastus cambelli *Dist., has been recorded from the Bismarck Archipelago, Bougainville, British Solomon Islands, Aignan (Misima) Island and the New Hebrides. Although it is widely distributed throughout the Bismarck Archipelago and Bougainville, high populations occur only on the Lihir group of islands.*

A parasite survey carried out on the Gazelle Peninsula revealed the presence of five A. cambelli *parasites. These include three egg-parasites—*Anastatus *sp. (Eupelminae),* Trissolcus painei *Ferr. (Scelionidae) and* Acroclisoides *?* megacephalus *Gir. (Pteromalidae); one nymphal parasite,* Aridelus *sp. (Braconidae); and one adult parasite,* Pentatomophaga bicincta *de Meij. (Tachinidae).* Aridelus *sp. and* A. ? megacephalus *are new* A. cambelli *parasite records.*

Whilst P. bicincta *is known to have oviposited on* A. cambelli *adults in the British Solomon Islands Protectorate, it apparently failed to develop in them. However, in Papua New Guinea it has been definitely proved to be an adult parasite.*

Of all the parasites the egg-parasites were by far the most important group of natural enemies of A. cambelli. *Among these,* T. painei *was the most common followed by* Anastatus *sp., while* A. ? megacephalus *became numerous only at irregular intervals.*

On the Lihir group of islands, only the two egg-parasites Anastatus *sp. and* T. painei *were recorded.*

The predacious ant Oecophylla smaragdina *F. appears to deter* A. cambelli *and the encouragement of this ant would undoubtedly be of great help in protecting palms from the ravages of* A. cambelli.

INTRODUCTION

Axiagastus cambelli Dist., the coconut spathe bug, has been recorded from Bismarck Archipelago, Bougainville, British Solomon Islands, Aignan (Misima) Island and the New Hebrides. (Lepesme 1947). Whilst the coconut palm (*Cocos nucifera*) is its principal host plant *A. cambelli* has also been recorded from betel-nut palm (*Areca sp.*) (Lever 1933b).

Whilst *A. cambelli* is distributed throughout the Bismarck Archipelago and Bougainville heavy populations only occur on the Lihir group of islands. The low populations observed on the Gazelle Peninsula, East New Britain, and elsewhere suggested that some natural control agents might be responsible for the low populations in these areas. In view of this, and because of the lack of knowledge as to what species of *A. cambelli* parasites occur in Papua New Guinea, investigations on the natural enemies of *A. cambelli* were commenced in 1969. Most of this work was carried out on the Gazelle Peninsula in 1969-1970.

Brief notes on the biology of *A. cambelli* have been given by Tothill (1929) and Lever (1933b). According to Tothill coconut leaflets are the preferred oviposition sites but Lever reported that the fibrous stipule was the preferred site, although eggs were also found on needle-like leaves of *Casuarina* sp. However on the Gazelle Peninsula, eggs have been found, usually in rows of 14, on coconut leaves, the undersides of spadix stipules, the fibrous material on frond edges and around the trunks, on spiderwebs between fronds and even on

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plants growing under the coconuts. Under laboratory conditions at Keravat the eggs hatched in six to eight days as against seven days as recorded by Lever (1933b).

The five nymphal instars occupy approximately 45 days (Lever 1933b).

Under laboratory conditions at Keravat field-collected adults lived for 14 to 21 days when fed on either coconut inflorescence or ripe fruits of a cluster palm (? *Ptychosperma* sp.). The pre-oviposition period is not known. However, no mating or oviposition was observed in freshly moulted adults which lived for about a fortnight in captivity.

Most of the previous investigations on the parasites and predators of *A. cambelli* have been carried out in the British Solomon Islands Protectorate. Tothill (1929) recorded 60 per cent parasitism of *A. cambelli* eggs by a chalcidoid and another unidentified hymenopterous parasite. These were later identified as a eupelmine, *Anastatus* sp., and a scelionid, *Microphanurus* sp., respectively, and although apparently distributed throughout the Islands, appeared to be of local importance only (Lever 1933a). Ferriere (1933) later described the two parasites as *A. axiagasti* Ferr. and *M. painei* Ferr.

Lever (1933c, 1934) studied the ovipositional behaviour and morphology of *M. painei* and *A. axiagasti* adults. In the field *M. painei* was nine times as numerous as *A. axiagasti* and the two were responsible for the destruction of about 64 per cent of the host eggs on one island.

No natural enemies have actually been introduced into the British Solomon Islands Protectorate for the control of *A. cambelli*. However, parasites introduced against more injurious pentatomids and coreids also took to *A. cambelli*. Thus *Trissolcus* (*Microphanurus*) *basalis* Wool., a scelionid egg-parasite of pentatomids, introduced from Sydney in 1941 for the control of the coreid *Amblypelta cocophaga* China, preferred *A. cambelli* eggs (Lever 1941) and soon established as a parasite of *A. cambelli* (Johns 1941).

Five egg-parasites of the Javanese coreids *Homoeocerus lucidus* Walk. and *Dasynus manihotis* Blote were introduced into the British Solomon Islands for the control of *A. cocophaga* (Phillips 1941). Two of these, *Ooencyrtus malayensis* Ferr. (Encyrtidae) and *Anastatus* sp. (Eupelminae), were also found to parasitize the eggs of *A. cambelli*.

The Australian (Queensland) tachinid, *Pentatomophaga bicincta* de Meij, introduced into the British Solomons in 1938-1939 to control *A. cocophaga*, apparently preferred to oviposit on *A. cambelli*. Whilst the eggs hatched, the larvae failed to develop in *A. cambelli* (Phillips 1956). Another tachinid, *Trichopoda pennipes* F., introduced from Florida in 1949 to control *A. cocophaga* and *Nezara viridula* L. in Fiji and the British Solomon Islands Protectorate, was also found to oviposit on *A. cambelli* (O'Connor 1950).

The ants *Anoplolepis longipes* Jerd. and *Oecophylla smaragdina* F. were recorded by Lever (1933b) as efficient predators of *A. cambelli*. However he has also stated that the ants *Iridomyrmex myrmecodiae* Emery and *Pheidole oceanica* Mayr. were antagonistic to these two beneficial species. In the Western Solomons there was almost complete absence of *A. cambelli* on coconut palms where *O. smaragdina* occurred and where *I. myrmecodiae* was absent (Lever 1933c).

GAZELLE PENINSULA OBSERVATIONS

Collections of *A. cambelli* adults, nymphs and egg-clusters were made at various times from localities throughout the Gazelle Peninsula. Field-collected nymphs and adults were placed in breeding cages and provided with either coconut inflorescence or ripe fruits of a cluster palm (? *Ptychosperma* sp.) as food. Moist soil or sawdust was placed at the bottom of the cages for parasite pupation. Egg-clusters were kept in 4 x 1 inch glass specimen tubes. *Ixora* sp. leaves were put into the tubes to provide moisture.

Parasites bred from the different stages of *A. cambelli* are listed below:—

Eggs

1. *Trissolcus painei* Ferriere (Scelionidae).
2. *Acroclisoides ? megacephalus* Girault (Pteromalidae).
3. *Anastatus* sp. (Eupelminae).

Nymphs

Aridelus sp. (Braconidae)

Adults

Pentatomophaga bicincta de Meij. (Tachinidae).

Whilst a parasitized egg-cluster of *A. cambelli* will usually yield one species of an egg-parasite it is not uncommon to find two species of any of the three parasites emerging from the one egg-cluster.

Notes on the bionomics, behaviour and possible importance of the various parasites are given below.

Trissolcus painei Ferr.

This is the most numerous and widely distributed egg-parasite of *A. cambelli* and is easily bred in the laboratory.

Under laboratory conditions a female can oviposit in more than 10 host eggs, each oviposition taking from three to five minutes. Although many instances of multi-oviposition were observed in the laboratory, only one individual of *T. painei* hatched from each egg following multi-oviposition.

Successful parasitism and development by *T. painei* was observed in host eggs one to seven days old at the time of oviposition. However, whilst the parasite larvae consumed the entire contents of the eggs when oviposition occurred in one to four day-old eggs only three-quarters of the contents were enough for complete development of larvae in eggs five or more days old.

A. cambelli eggs parasitized by *T. painei* developed a dark meridional band some four to five days (average 4.2 days) after being parasitized and this was constant in all eggs parasitized between one and seven days. The remainder of the parasitized egg remained white until a day or so before the emergence of the adult parasite, whereupon it turned black. The dark meridional band persisted on the egg shell even after the parasite had emerged.

The parasites emerge from the host eggs through an irregular hole in the operculum, usually between 7 and 11 a.m.

The development period of *T. painei* in 427 host eggs ranged from 12 to 15 days (average 13.5) with approximately 91 per cent of the parasites developing successfully.

The longevity of *T. painei* adults in captivity varied from one to five days depending on whether they were fed and whether they oviposited or not. When fed on honey solution and allowed to oviposit, they lived for one to two days; when given no food and not allowed to oviposit, two to four days; and when given food but no host eggs to oviposit in, they lived for three to five days.

It is thought that the abundance of *T. painei* over other egg-parasites of *A. cambelli* may result from its persistent ovipositional behaviour, as it continues to oviposit even when being walked over or pushed by other competing individuals.

The ovipositional behaviour of *T. painei* has also been discussed by Lever (1933c).

T. painei has also been bred from eggs collected from the Lihir group of islands.

Anastatus sp.

Since adults of *Anastatus* sp. are easily disturbed by the approach of other individuals when ovipositing, it was not possible to make detailed studies of the behaviour of this species. However Lever (1933c) has given a good account of the ovipositional behaviour of a related species *A. axiagasti*.

Anastatus sp. does not seek out the host eggs as avidly as *T. painei*, and mating does not occur readily. *A. cambelli* eggs parasitized by *Anastatus* sp. do not develop the meridional band, but gradually assume a brownish colour. The adult parasite emerges through the operculum of the host egg through a more or less circular hole. The total development period within the host eggs is about 16 days.

An *Anastatus* sp. has also been bred from *A. cambelli* eggs collected from the Lihir group of islands but it is not known if this is the same species which occurs on the Gazelle Peninsula.

The species of *Anastatus* recorded from *A. cambelli* eggs in the British Solomon Islands Protectorate is *A. axiagasti*. *A. axiagasti* is also known to attack the eggs of *Amblypelta cocophaga* in that area (Phillips 1956).

Acroclisoides ? megacephalus Gir.

This is the first record of *A. ? megacephalus* from *A. cambelli* eggs. *A. ? megacephalus* is comparatively less common than either of the other two egg-parasites present on the Gazelle Peninsula. Although it occurred at all the sites, it was only bred in any numbers from the Napapars. Most of the individuals bred from field-collected parasitised host eggs were males.

A. cambelli eggs parasitized by *A. ? megacephalus* also develop a meridional band. However, the band is much darker than that developed by *T. painei* parasitized eggs, but unless *A. ? megacephalus* parasitized eggs are compared with those parasitized by *T. painei*, they are very difficult to separate using this factor.

This species has not been recorded from the Lihir group of islands.

Pentatomophaga bicincta de Meij

P. bicincta has been bred from *A. cambelli* adults collected from all localities under investigation on the Gazelle Peninsula, but in very small numbers. By far the greater number have been bred from adults collected from Tavilo Plantation. It is an internal parasite of *A. cambelli* adults. To pupate, the fully grown larvae emerge from the parasitized host through the anal part of the abdomen. The pupal period in a few individuals observed varied from 17 to 19 days.

P. bicincta does not appear to be of great significance as an *A. cambelli* biocontrol agent.

It has not been recorded from the Lihir group of islands.

Aridelus sp.

This unidentified braconid would appear to be the first record of a nymphal parasite of *A. cambelli*. It first showed up when a sluggish-looking nymph which had been isolated from the bulk rearing cage was found dead on the following day with the dorso-posterior portion of its abdomen ruptured. The white pupal cocoon of the parasite was found attached to the side of the tube containing the host nymph.

The braconid has so far only been recovered from nymphs collected from the Napapars, but its parasitism rate has always been low.

It has not been recorded from the Lihir group of islands.

Predators—Ants

Among the species of ants predaceous on various stages of *A. cambelli*, kurukum ants (*Oecophylla smaragdina* F.) when nesting or foraging on coconut palms, appear to give very good protection from *A. cambelli*. The encouragement of *O. smaragdina* to establish on coconuts would undoubtedly be of great help in protecting palms from the ravages of *A. cambelli*.

CONCLUSIONS

A survey of the natural enemies of *A. cambelli* occurring on the Gazelle Peninsula revealed the presence of three egg-parasites, one nymphal parasite and one adult parasite. Among the egg-parasites, *T. painei* was the most common and important, followed by *Anastatus* sp. Appreciable numbers of *A. ? megacephalus* appeared only at irregular intervals. The populations of both the braconid *Aridelus* sp. and the tachinid *P. bicincta* always remained low. The recording of *A. ? megacephalus* and *Aridelus* sp. from *A. cambelli* are new parasite records. The first recorded breeding of the tachinid from *A. cambelli* was obtained during this survey.

Whilst the very low populations of *Aridelus* sp. and *P. bicincta* on the Gazelle suggest that these may not be of appreciable importance as biocontrol agents on their own, it is possible that their effect on the control of *A. cambelli* may be important when the effect of all the parasites is summed.

From the Lihir group of islands, the only parasites recorded were the egg-parasites *Anastatus* sp. and *T. painei*.

In view of the abundance of *A. cambelli* parasites in the Gazelle Peninsula, it seems that this insect is possibly indigenous to Papua New Guinea.

It is well known that insects which become established in new areas often reach harmful proportions when their natural parasites and predators are not present. Introduction of parasites or predators of these insects can be of benefit in controlling outbreaks. Parasites and predators of insects indigenous to Papua New Guinea may also be of value in controlling related insects in other countries. Thus a general survey of natural enemies of Papua New Guinea insects may be worthwhile and might prove of benefit to other countries.

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THE DETERMINATION OF SEXES OF THE CACAO WEEVIL BORER *PANTORHYTES SZENTIVANYI* MARSHALL (COLEOPTERA: CURCULIONIDAE)

E. HASSAN*

ABSTRACT

A rapid and simple method for sexing Pantorhytes szentivanyi *Marsh. adults by visual examination of the ventral abdominal sternites is described.*

INTRODUCTION

P. szentivanyi Marsh. is an important pest of cacao (*Theobroma cacao*) in the Northern District of Papua New Guinea (Szent-Ivany and Ardley 1963).

Marshall (1957), when he originally described *P. szentivanyi*, stated that the only difference between the sexes was that "the hind tibia are flattened on the inner face and quite smooth on both sides in the male, but rugulose on the inner side in the female". Whilst this character is certainly consistent, it can only be determined by microscopic examination.

The necessity to develop a rapid method of sexing adults without microscopic genitalia examination became apparent when *P. szentivanyi* laboratory and field population studies were commenced in April 1968.

METHODS AND RESULTS

Over 6000 field-collected *P. szentivanyi* adults were closely studied under the microscope for morphological characters which could be used to differentiate the sexes.

Many characters were initially selected for examination, but were abandoned when it became obvious that they were highly variable. These included differences in size, colour, punctuation of cuticle, shape of the body, legs, antennae, eyes, mouth parts and of the head, particularly the width and depth of a frontal groove of both sexes. None of these alone or in various combinations were found consistent enough to provide a reliable indication of the sex.

After failing to find any obvious morphological differences, male and female beetles were separated by examination of genitalia. This material was then closely studied for sexual differences in morphological features.

Using this method, clear and consistent differences in the shape of the first, second, seventh and eighth abdominal sternites were observed and these are described below:—

To detect the sexual differences in living or dead weevils, the adult specimen must be held upside down to view the ventral abdominal segments clearly. The fifth segment must be lifted or excised to expose the seventh and eighth sternites.

In the male, the first and second sternites are almost flat, and clearly separated by a complete, anteriorly curved suture which bears a pit like depression at the mid-ventral line as shown in *Figure* 1A.

In the female, the first and second sternites are fused into a single, large, solid, somewhat swollen plate, in which the dividing suture is only visible on the sides, and the mid-ventral pit is reduced to a broad, shallow depression as shown in *Figure* 1B.

When viewed ventrally, only five segments are normally visible. To expose the seventh and eighth abdominal segments, the fifth segment must be lifted or excised. In both sexes, the dorsum of the vestibulum is a single plate with bluntly conical tergites. The venter consists of two sclerites (7th sternite) in the male, and in the female is made up of a single sclerite (8th sternite as shown in *Figures* 2A and B).

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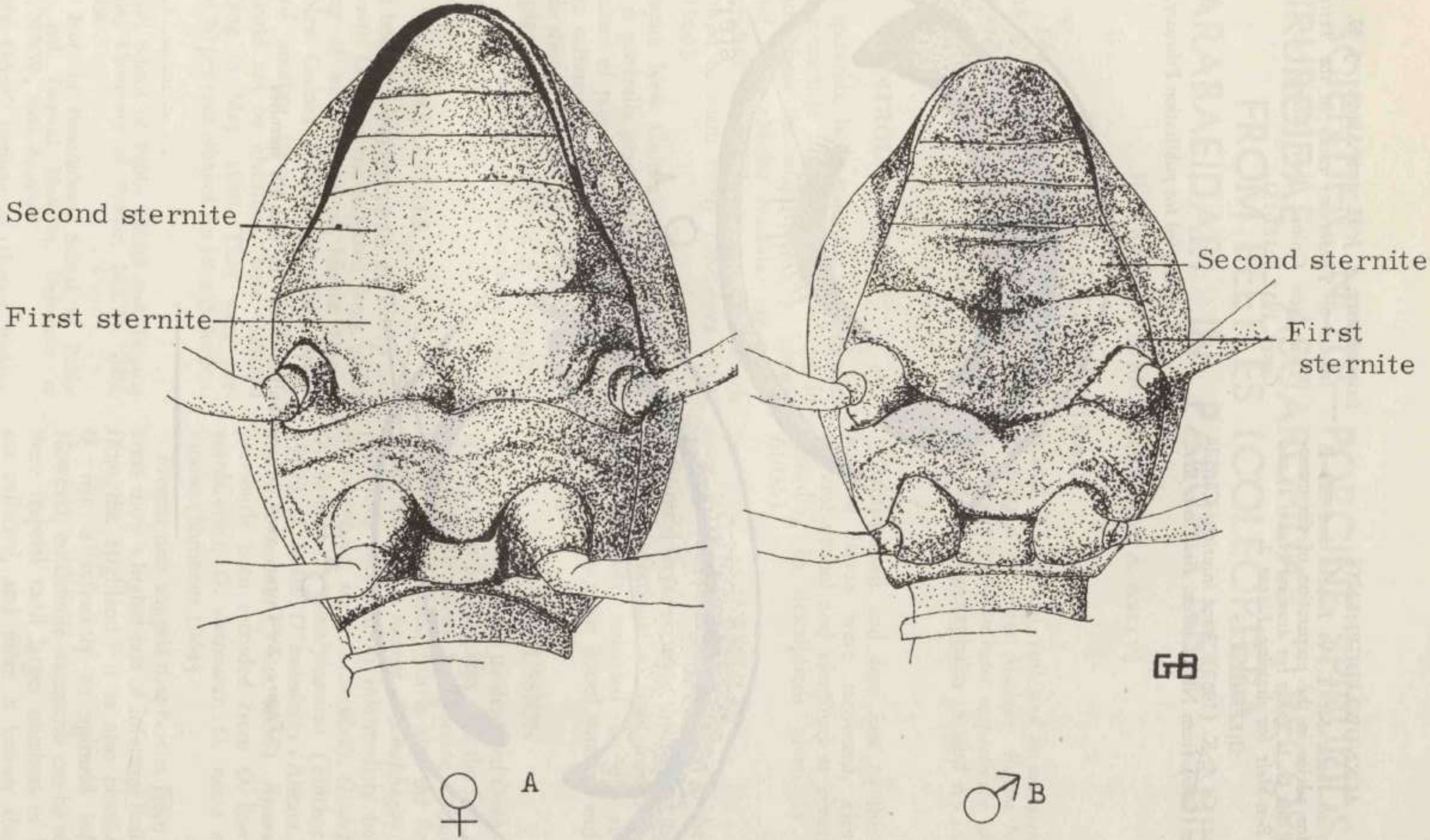

Figure 1.—Structure of the ventral abdominal segments

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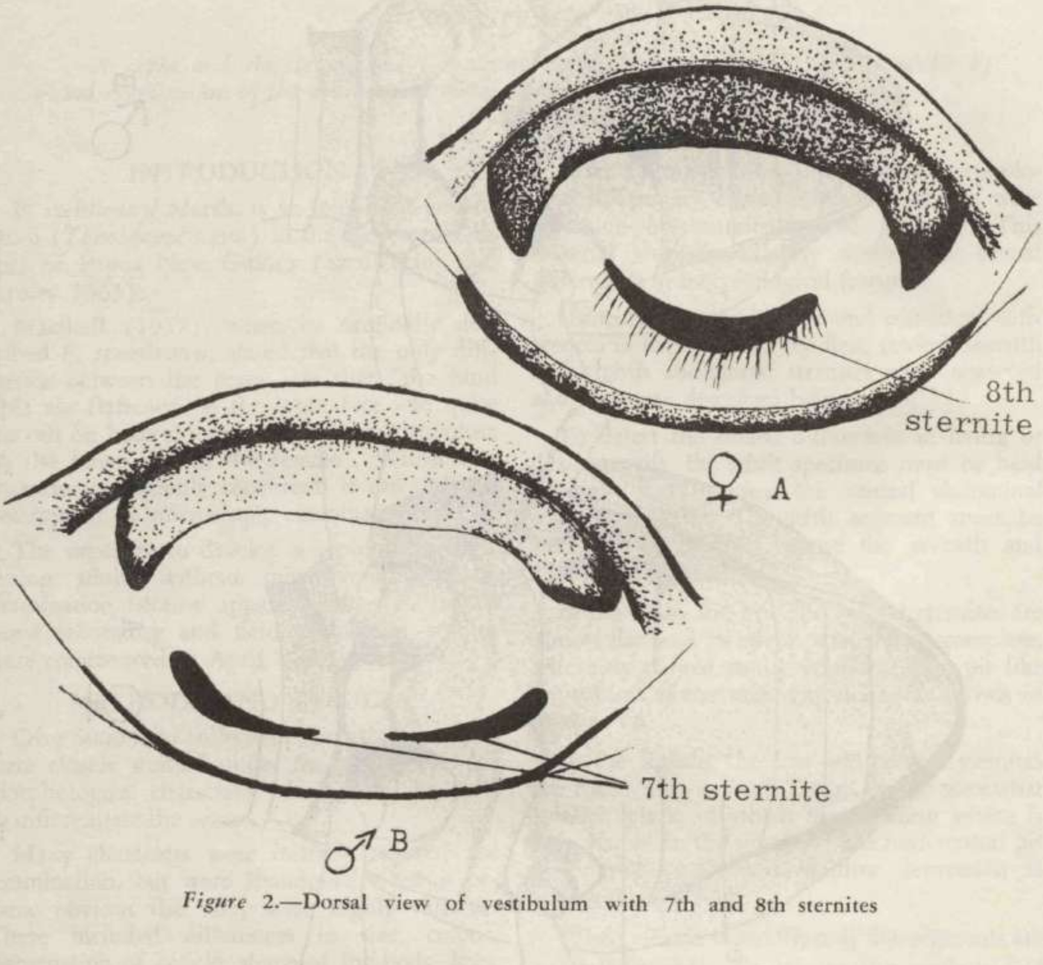

Figure 2.—Dorsal view of vestibulum with 7th and 8th sternites

SCIENTIFIC NOTE—PORCINE SPIRURIDS (SPIRUROIDAE : ASCAROPIDAE RECORDED FROM BEETLES (COLEOPTERA : SCARABAEIDAE) IN PAPUA NEW GUINEA

R. WATKINS*, B. McMILLAN† AND A. KELLY‡

ABSTRACT

The Scarabaeine beetles Onthophagus iris *and* O. ? heurni, *collected in association with pig dung near Mount Hagen, and* Onthophagus *sp. from Madang, Papua New Guinea, show* 0 *per cent,* 69 *per cent and* 76 *per cent infection rates respectively, with first to third stage larvae of the Ascaropidae nematodes* Physocephalus *sp. and* Ascarops *sp.*

INTRODUCTION

TWO spirurids, both requiring dung-beetles as intermediate hosts, commonly occur in pigs throughout the world. *Ascarops strongylina* and *Physocephalus sexalatus* are particularly evident in wild boars and pigs which are allowed to roam freely (Shmitova 1961, Jansen 1966).

In Papua New Guinea where open range grazing is generally practised and breeding and management of pigs is loosely controlled, spirurids are commonly present. Talbot (personal communication) lists the known spirurid parasites of pigs as *Ascarops dentata, A. strongylina, Physocephalus sexalatus, Gnathostoma doloresi* and *Simondsia paradoxa.*

MATERIALS

Dung beetles, identified as *O. iris* Sharp and *O. ? heurni* Gillet, were collected from under the dung of village pigs at Mount Hagen, Papua New Guinea in February, 1969. Specimens of another species of *Onthophagus*, which could not be identified, were collected at Madang in May, 1969. They were preserved in 70 per cent ethanol for later dissection.

Encapsulated and free first to third stage spirurid larvae were recovered, cleared in glycerol-alcohol and identified at generic level according to descriptions given by Alicata (1935).

RESULTS

Results of dissections are given in the *Table.*

Spirurid larvae occurred throughout the beetle in heavy infections; in light infections larvae were generally restricted to the abdomen, especially along the dorsal surface, and in the fat body.

DISCUSSION

O. ? heurni and the unidentified *Onthophagus* species from Madang represent the first demonstrated beetle hosts for porcine spirurids in Papua New Guinea; this is also the first host record for *O. ? heurni. Onthophagus* species previously recorded as intermediate hosts for *Physocephalus* are: *O. concinnus, O. depressus, O. hecate, O. pennsylvanicus* (Fincher *et al.* 1969), *O. bedeli, O. nebulosus* (Alicata 1935), and *O. praedatus* (Yutuc 1966). *Ascarops* has previously been recorded from *O. taurus, O. muchicornis, O. austriacus, O. vacca* and *O. vitulus* (Shmitova 1964).

Present data suggest that beetles from coastal areas show a higher rate of infection than those from the Highlands; it is also possible that *O. iris* is refractory to spirurid infection. However, no definite statements can be made in these respects until larger numbers of beetles are collected, and more is known about the habits of the different species of *Onthophagus.*

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Table.—Details of spirurid larvae obtained from beetles

	MOUNT HAGEN		MADANG	
	Onthophagus Iris	Onthophagus ? heurni	Onthophagus sp.	
			Male	Female
No. examined	10	26	10	19
No. infected	0	18	9	13
Per cent beetles infected	0	69	90	68
			76	
Physocephalus sp.—3rd stage larvae		249	286	598
Ascarops sp.—3rd stage larvae		2	9	97
First stage larvae			455	100
Total No. of larvae		251	750	795
Av. No. of larvae/beetle		14	83	61

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