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A HYBRID BETWEEN *PAPILIO ÆGEUS ÆGEUS* AND *PAPILIO FUSCUS CAPANEUS*, WITH A NOTE ON LARVAL FOODPLANTS

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Papilio ægeus Donovan and *Papilio fuscus* Goeze are closely related species. They are very similar in their morphology, but differ markedly in one respect, namely that the former shows sexual dimorphism while the other does not. *P. ægeus* occurs in various races throughout New Guinea and in Eastern Australia as far south as Canberra, while *P. fuscus* is rather more widely distributed extending westwards into the Indo-Malayan region, but in Australia southwards as far as Brisbane.

In south-eastern Queensland *P. ægeus ægeus* is a common species, the larvæ occurring on a variety of rutaceous plants in several genera. *P. fuscus capaneus* Westwood, however, is usually less common and may not be seen for several years. Its larvæ have been found on only a few species of rutaceous plants. (See Table 1A)

During 1959, both species were common in the Brisbane area and attempts were made to cross-mate them, as described below. Generally results follow the pattern reported by other workers with this genus, e. g. REMINGTON (1960) and AE (1960). The matings were carried out by fixing the individual specimens very gently on the top of blocks of balsa wood. The closed wings were covered with paper strips, fixed with a pin at each end, while the legs and lower parts of the abdomen protruded from the side of the block. A male and a female were then brought together and the anal claspers of the male gently opened with a pair of forceps. The abdomen of the female was then pushed between the claspers taking great care to lock the claspers in the right position. The successfully mated female was kept in a dark box for five to six days and fed daily with a 10% to 15% sucrose solution. She was then released in a large cage in which young shoots of *Citrus* were placed.

The first experiments using males of *P. fuscus* and females of *P. ægeus* were unsuccessful. This was possibly due to the anal claspers of the males being rather small and thus having little or no grip on the anal segments of the females. Only in one instance did copulation succeed, but the spermatophore was lost.

The experiment was then reversed and a small male of *P. ægeus* was successfully mated with a relatively large female of *P. fuscus*. The oviposition gave the following results:

Date of oviposition	Eggs laid	Eggs hatched
September 15	16	11
September 19	15	5
September 21, 22	45	36
Totals	76	52 (hatchability 68.4%)

After oviposition, the eggs were fixed to a filter paper by applying a very weak solution of gum to their flattened base, and kept in a petri dish until they hatched. This method gave excellent results. As soon as the larvæ hatched, they were divided into three groups, each of which was kept in a petri dish and was offered a different host plant. Those to be reared singly were isolated when they reached the second instar.

Of the 52 larvæ, 16 were reared singly and the remainder together. Mortality was highest amongst the individually reared specimens, of which only 13 reached maturity, and of these only one pupated normally. The others failed to produce the silk girdle for pupation and lay as prepupæ at the bottom of their cage. They were therefore helped into girdles of exuviae, and as a result 6 of them proceeded to pupate. The others were deformed and perished. The 36 specimens reared together showed a low mortality; 26 reached maturity, of which 22 pupated normally and only 4 failed to produce the silk girdle. Larvæ were reared on three different hostplants: a) citrus (*C. reticulata*), b) parsley (*Petroselinum crispum*) and c) camphor laurel (*Cinnamomum camphora*) with the results shown in Table 2.

The 9 specimens reared together on camphor laurel died in their early instars although they accepted this host readily. Feeding experiments carried out at the same time with larvæ of *P. ægeus* showed similar ill-effects after eating camphor laurel leaves grown in the spring. Previous experiments with *P. ægeus* conducted at a different time of the year gave good results, and it seems possible that a concentration of toxic elements builds up in the buds of the camphor laurel during the winter months, thus causing the death of larvæ feeding on the resulting leaves in the spring (Stride & Straatman 1962).

Table 1. HOST PLANT OBSERVATIONS ON *PAPILIO ÆGEUS* & *FUSCUS*

A. Host plants on which wild females of both species have been observed to oviposit or on which larvæ were collected in the field. All are Rutaceæ. (Asterisk indicates introduced plants.)

<i>Papilio ægeus ægeus</i>	<i>Papilio fuscus capaneus</i>
* <i>Citrus aurantium</i> L.	* <i>Citrus aurantium</i>
* <i>C. sinensis</i> (L.) Osbeck	* <i>C. sinensis</i>
* <i>C. reticulata</i> Blanco	* <i>C. reticulata</i>
* <i>C. limon</i> (L.) Burm.	* <i>C. limon</i>
* <i>C. paradisi</i> Macfayden (occasional larvæ)	* <i>C. aurantiifolia</i>
* <i>C. aurantiifolia</i> (Christm.) Swingle	<i>Microcitrus australasica</i>
* <i>Choisya ternata</i> H. B. et K.	<i>Zanthoxylum brachyacanthum</i>
<i>Flindersia bennettiana</i> F. Muell.	
<i>F. collina</i> F. M. Bail.	
<i>Microcitrus australasica</i> (F. Muell.) Swingle	
<i>M. australis</i> (Planch.) Swingle	
<i>Geijera salicifolia</i> Schott	
<i>Zanthoxylum brachyacanthum</i> F. Muell.	

B. Other plants, accepted in the laboratory by larvæ of *P. ægeus*, but not by *P. fuscus*.

Rutaceæ	Umbelliferæ
<i>Flindersia xanthoxyla</i> Domin.	* <i>Daucus carota</i> L.
<i>F. australis</i> R. Br.	* <i>Petroselinum crispum</i> (Mill.) Nyman.
	* <i>Apium graveolens</i> L.
Meliaceæ	
<i>Owenia venosa</i> F. Muell.	Capparidaceæ
	<i>Capparis nobilis</i> F. Muell.
Lauraceæ	Aristolochiaceæ
* <i>Cinnamomum camphora</i> (L.) T. Nees et Eberm.	* <i>Aristolochia elegans</i> Mast.

C. Rutaceous plants not accepted by either species in the laboratory.

Evodia micrococca F. Muell.
Medicosma cunninghamii (Hook.) Hook. f.
Acronychia baueri Schott
A. pauciflora C. T. White

Table 2. SURVIVAL OF F₁ HYBRID LARVÆ ON VARIOUS FOOD PLANTS

	Number of larvæ tested on:			Died as pre-pupæ	Total tested	Total died	Total pupated
	Citrus ¹	Parsley ¹	Laurel ¹				
Singly	11 [1]	5 [2]	0 [0]	6	16	9	7 ²
Grouped	18 [0]	9 [1]	9 [9]	4	36	14	22
Totals:	29 [1]	14 [3]	9 [9]	10	52	23	29

¹In brackets is the number of these that died as larvæ.

²Six of these pupated when assisted (see text).

The 29 pupæ produced 26 males and 3 females. The males emerged normally but the 3 females, although fully developed, were unable to emerge. The males were large in comparison with the size of their pupæ; 15 of these were used for back-crossing to females of both parent species. In most cases copulation was normal and the mated females produced a large number of eggs, but all were sterile.

DESCRIPTION OF LARVÆ

I. FIRST INSTARS.

A. *P. fuscus*: - Head black with short setæ. Ground colour yellowish grey. First thoracic segment orange yellow dorsally and with four tubercles of which the two dorsal ones the longest, yellowish white and with stiff whitish hairs; lateral tubercles short, brown with hairs. Remaining thoracic segments each with six tubercles, of which the dorsal ones the longest, yellowish, with whitish hairs; lateral tubercles rather short, brown. Abdomen yellowish grey; third segment white dorsally and ventrolaterally down to the prolegs; fourth and ninth segments white dorsally. All abdominal segments with six rather short tubercles, the dorsal ones on the eighth and ninth rather longer and yellowish white. Legs black, prolegs brown. When moult nears, the general appearance is shiny brown.

B. *P. ægeus*: - Head black with short setæ. Ground colour brownish black. First thoracic segments white dorsally and dorso-laterally and with six tubercles at the lateral, latero-dorsal and dorsal levels respectively; the latero-dorsal tubercles white and larger than any other tubercles of the larva. Second thoracic segment white dorsally and the third white dorso-laterally, with eight tubercles each, of which the dorso-lateral ones are white on the second and black on the third thoracic segments. Abdomen: first, second, fifth, sixth and seventh abdominal segments brown-black, with black tubercles, eight on the first and six on the others; third fourth, eighth and ninth segments white dorsally and dorso-laterally, with six white tubercles each, those on the eighth and ninth the longest; all tubercles have spines and hairs; anal segments with black setæ. Underside uniformly black.

C. HYBRID: - Head black with short setæ. First thoracic segment white, with four tubercles at the lateral and dorso-lateral levels, those at the latter level the longest, white and inclined posteriorly. Second and third thoracic segments dark greyish brown with six small black tubercles each. Abdomen: first and second segment dark brown, with six short black tubercles each, the dorsal ones slightly longer; third, fourth, eighth and ninth segments yellowish white with six short tubercles each, the dorsal ones on the eighth and ninth the longest; fifth, sixth and seventh segments dark grey-brown, tubercles black, rather short; all tubercles are fleshy with greyish hairs and black spines; anal segments and underside of all segments dark brown. Legs black, prolegs brown.

II. THE INTERMEDIATE INSTARS.

A. *P. fuscus*: - Head black with short setæ. From the second to the fourth instar, the ground colour becomes gradually browner. Dorsal tubercles of first thoracic segment orange brown, fleshy with short stiff hairs. Tubercles of second and third thoracic segments rather short, brown. Abdominal segments paler brown dorsally; tubercles rather short, brown, those on the eighth and ninth abdominal segments longer, orange-brown; all tubercles have a bluish dot near the base; a white area is present laterally on the second, third, fourth, seventh and eighth abdominal segments; on the third segment it extends transverse-dorsally and laterally. Prolegs dark grey, white laterally, and with dark spots between them.

B. *P. ægeus*: - In the intermediate instars, of which no detailed description was made, the ground colour varies from greenish ash-grey to almost black. The white dorsal and lateral areas are distinct. Tubercles comparatively much longer than in *P. fuscus*. Small, irregular stripes and spots are present, and in the penultimate instar there are blue spots dorsally. All these marks vary considerably in shape and density.

C. HYBRID: - Head shiny black, with fewer setæ than in the first instar. Second instar with first thoracic segment white and with two long white fleshy tubercles, inclined posteriorly. Second thoracic segment light brown dorsally, with white markings and short brown tubercles. Third thoracic and first abdominal segments dark coffee-brown with two short dorsal and two rather short lateral tubercles. Other abdominal segments dark brown. White areas extend dorsally on the third and eighth, dorso-laterally on the fourth and seventh, and ventro-laterally on the sixth abdominal segments. Tubercles rather short, brown, except those on the seventh and eighth abdominal segments, which are longer and white.

In the third and fourth instars the colour becomes gradually yellowish brown, white markings more distinct and tubercles shorter. Those on the first thoracic segment yellow and the abdominal tubercles have a small, blue sub-basal dot. The second abdominal segment broad white laterally, and a broad, white subspiracular stripe runs posteriorly from the third abdominal segment. Legs black, prolegs greyish.

III. THE FINAL INSTARS.

A. *P. fuscus*: - There are two forms, of which the brown form is the most common.

Brown Form. Head pale greenish brown. Ground colour orange-brown. Thoracic and the first two abdominal segments with a ventro-lateral dark brown area, extending laterally, but narrowing dorsally on the posterior margin of the first abdominal segment, thus forming a ring, which however is not as wide and distinct as in *P. ægeus* larvæ. First two thoracic segments have the dorsal margin of this dark area bordered by creamy yellow, which fades out into a few indistinct stripes on the third thoracic segment. Two fleshy short tubercles present on the first thoracic and on the eighth and ninth abdominal segments, these tubercles brown and tipped with yellow. All other segments smooth. Dorsally the thoracic segments have four and the abdominal segments six round, blue spots. A broad white to pinkish subspiracular stripe runs from the

second abdominal to the anal segments, extending postero-laterally on the fourth abdominal segment to form a wedge-shaped spot. This spot has its dorsal margin broadly marked with dark brown, forming a saddle-mark, which however is not as distinct as in *P. ægeus*. A much smaller dark brown spot is present at the base of the anterior end of the sixth abdominal segment. All segments with small, whitish dots and irregular stripes dorsally and laterally, forming a more distinct yellowish white area on the seventh and eighth abdominal segments. Anal segments dark brown with yellow markings. Legs ochreous, prolegs light grey.

Green Form. Head ochreous green. Yellowish white markings and blue spots reduced and indistinct, giving the larva a uniform green appearance. The dark brown markings however are much more distinct than in the brown form, while the subspiracular stripe is broader and more pinkish. The dorsal tubercles on the eighth and ninth abdominal segments are smaller than in the orange form, and green. Legs yellowish green, prolegs white.

B. *P. ægeus*: - The most common form is green in colour, usually with numerous irregular yellowish white oblique stripes and dots. These vary individually and are sometimes totally absent. First thoracic segment with six tubercles, remaining thoracic and the first abdominal segments with eight tubercles each, the latero-dorsal pairs being the longest. All other abdominal segments have two tubercles dorsally, which are black on the fifth, sixth and seventh segments and yellowish green on the others. The brown ventral area on the thoracic segments extends laterally and narrows dorsally on the posterior half of the first abdominal segment, forming a distinct ring. The intersegmental membrane between the first two abdominal segments velvet-black, but only visible when larva is disturbed. A distinct, olive brown saddle-mark runs from the dorso-lateral region of the fifth segment down to the ventro-lateral region of the fourth segment, while a similar but much smaller mark is present anteriorly on the ventro-lateral part of the sixth abdominal segment. Anal segments marked with black and yellow. Subspiracular stripe broad and pinkish white. Legs olive brown, their dorsal margin white. Prolegs pinkish pale green, the first pair broadly the others narrowly marked with a transverse black stripe. A second form is more yellowish green with the white markings broader and very distinct. The dark areas, including the saddle mark, are reduced. Some specimens have a pinkish white saddle mark.

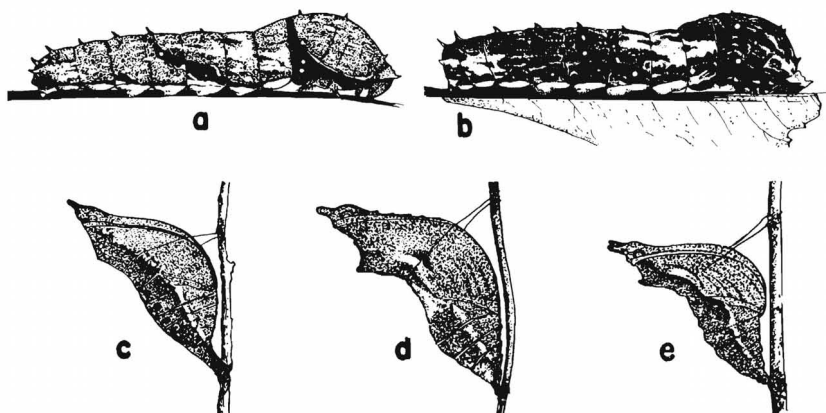
C. HYBRID: - As in *P. fuscus*, there were green and brown forms, the green one resembling *P. ægeus* and the brown form *P. fuscus*. In the

first form all segments are green, with numerous faint, yellowish irregular markings and two to four blue spots each, large on the first, fourth and fifth abdominal segments, but small on the others. A slightly more distinct, broad, whitish area extends laterally on the second and eighth and dorso-laterally on the third and fourth abdominal segments, where it fades out. With the exception of the second and third abdominal segments, all segments with two dorsal tubercles, each very short, yellow and without dark tips on the thoracic and the first abdominal segment, very short and green on the fourth segment, longest, yellow with black tips on the eighth and ninth segments, intermediate in length, dark green and with black tips on all other segments. Subspiracular white stripe broad on the fourth and sixth abdominal segment, but otherwise narrower than in the parent species' larvæ. A long, distinct, oblique, olive brown saddle-mark runs dorso-laterally from the fifth abdominal segment and widens laterally down to the anterior part of the fourth abdominal segment. It is bordered by two small white marks, a dorsal one on the fourth and a ventral one on the fifth segment. A similar dark stripe present at the anterior end of the sixth abdominal segment, below the spiracle. Anal segments marked with black. Legs greenish yellow, prolegs white. (See figure a, opposite.)

The orange-brown form has the thoracic segments with white longitudinal stripes dorsally. All other white markings broad and distinct, and the dark markings on the thoracic segments very broad. Blue spots large and distinct on the first, second, fourth and fifth abdominal segments. (See figure b, opposite.)

IV. THE PUPAE.

A. *P. fuscus*: - The colour is usually green, rarely light brown. Intermediate forms have not been recorded. Pupa smooth and rather broad dorsally, its greatest width about half of the total length. Head with two short anterior horns, which diverge slightly and are dark pinkish brown in colour. The dorsal bend rather shallow and without a mid-dorsal thoracic process. Ventrally the pupa is green, without markings. The inner margin of the wingcases bordered by a row of pinkish white spots, which continues on the abdominal segments as a definite stripe, pinkish brown in colour and with its dorsal and ventral margin bordered by white. Cremaster broad, and dark pinkish brown. Dorsally, the first seven abdominal segments with four distinct greenish black dots each, the eighth segment with only two dots and the following segments none. The silk girdle rather weak and often breaks. However, the pupa is strongly supported by the cremaster, which is flattened and sufficiently

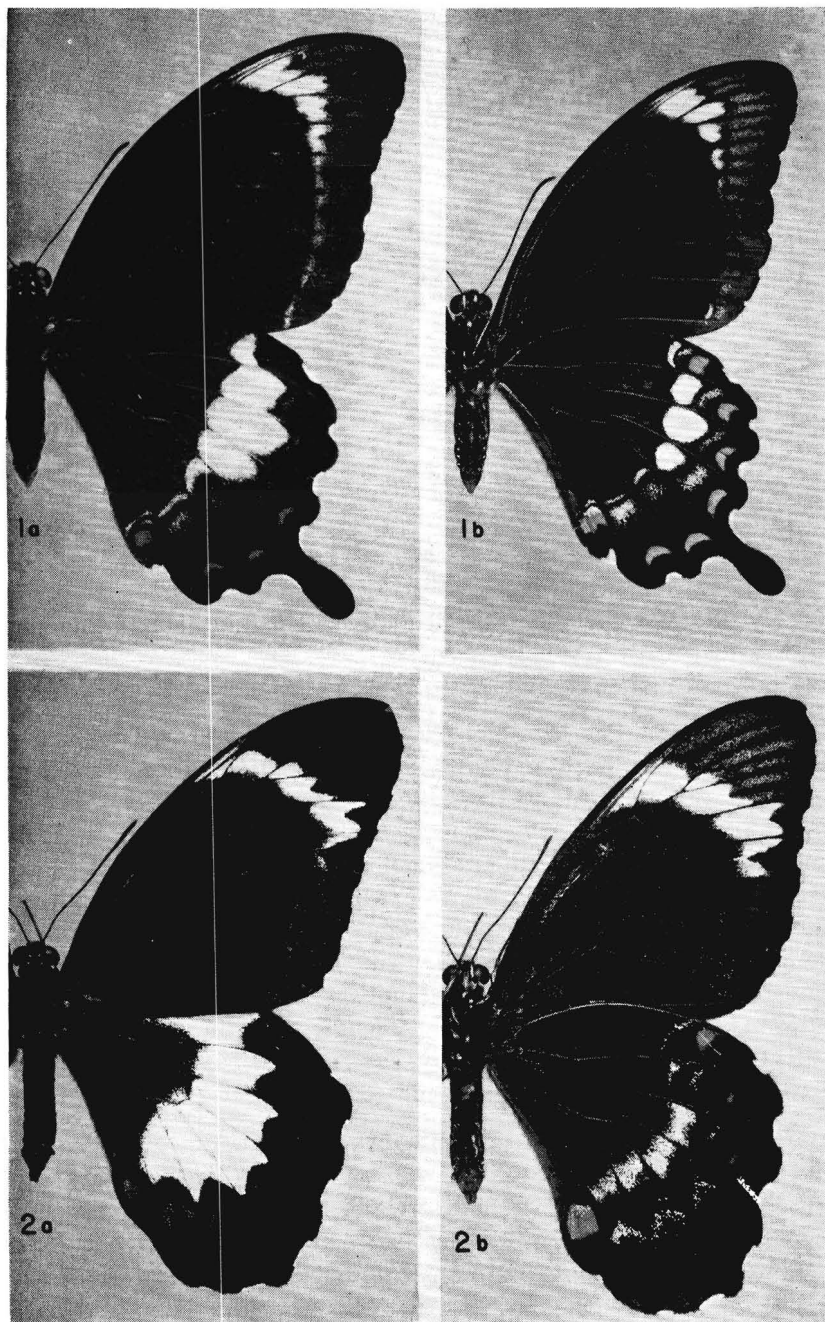


a) mature larva, F_1 hybrid (\varnothing *Papilio fuscus* \times δ *P. ægeus*), green form; b) same, brown form; c) pupa, *Papilio fuscus*; d) pupa, *P. ægeus*; e) pupa, F_1 hybrid (\varnothing *P. fuscus* \times δ *P. ægeus*).

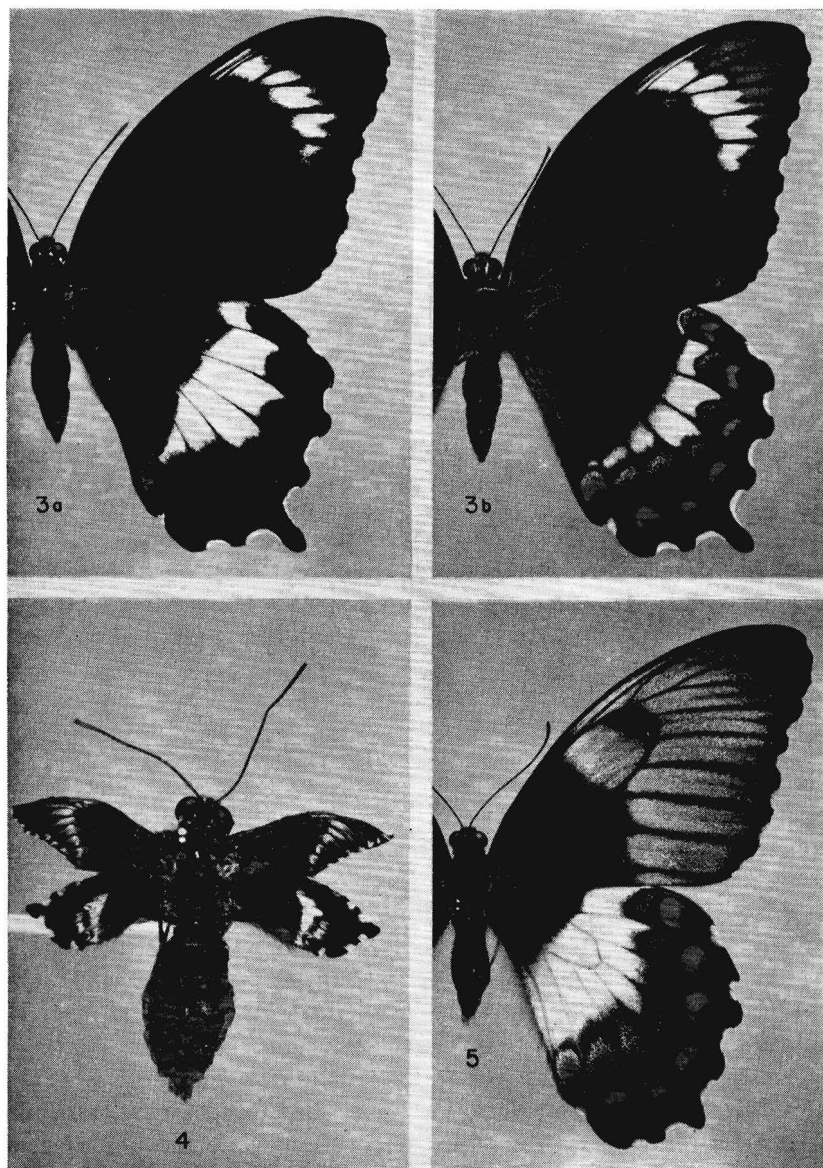
strongly attached to hold the pupa erect. The duration of the pupal stage varies greatly and may be several years. The pupa is sluggish and does not move when disturbed.

B. *P. ægeus*: - Ground colour varying from whitish grey to almost black, or bright green. The mid-dorsal thoracic process small and directed a little forwards. Dorsal bend sharply curved. Green pupæ have a broad lemon-yellow saddle-mark on the first three and a smaller, similar mark on the last three abdominal segments. Usually the wing-cases with a whitish streak on their inner margin and the abdominal segments with a similar strip laterally. Ventrally, four tiny tubercles present on the legs, and dorsally the fourth and fifth abdominal segments with two short, blunt humps each. The cremaster smaller and weaker, while the silk girdle stronger than in *P. fuscus*; if the girdle breaks, the pupa falls forward. The pupal stage lasts for a minimum of 13 days and may last several months (in winter).

C. HYBRID: - The pupa of the hybrid variable in colour. As in *P. ægeus* the dorsal bend sharply curved. Mid-dorsal thoracic process short, dark brown and directed straight forward. Abdominal segments rounded dorsally, but without humps. Head with the two anterior horns, these slightly longer than in either parent and tipped dark brown. As in *P. fuscus*, abdominal segments with a distinct pinkish lateral stripe and with faint black dots dorsally. The brown pupæ with all markings faint. Pupa, sensitive especially when disturbed. Duration: 14-17 days.



1a) *Papilio fuscus* ♂, upperside; 1b) same, underside; 2a) *P. ægeus* ♂, upper-
side; 2b) same, underside.



3a) ♂ F_1 hybrid (\varnothing *Papilio fuscus* \times ♂ *P. ægeus*), upperside; 3b) same, underside; 4) ♀ F_1 hybrid, upperside (deformed due to inability to eclose); 5) *P. ægeus* ♀, upperside. The ♀ of *P. fuscus* closely resembles the ♂ (see Fig. 1a).

V. THE ADULTS.

A. *P. fuscus*: - The male resembles the female, showing the pattern as illustrated in Plate 1, figs. 1a, 1b. Both sexes have tailed hindwings.

B. *P. ægeus*: - Sexually dimorphic. The females (Plate 2, fig. 5) are usually larger than the males and vary greatly in colour. Nearly white forms have been described. Males (figs. 2a, 2b) however are constant in their colour pattern. Both sexes are without tails on the hindwings.

C. HYBRID: - Adult males (figs. 3a, 3b) show a general appearance which is intermediate between that of the parental species and have short tails on the hindwings. On the dorsal surface the pattern closely approaches that of *P. ægeus* while on the ventral surface the pattern is rather more like that of *P. fuscus*. As far as can be judged from the unexpanded wings of the female (fig. 4), their pattern is also intermediate between the parent species.

A series of specimens has been lodged in the Division of Entomology Museum, C.S.I.R.O., Canberra.

DISCUSSION

The production of viable hybrids between *P. ægeus* and *P. fuscus* confirms the close relationship of these two species which is also apparent from their morphology. As is usual in these crosses (*e.g.* Remington, 1960; Ae, 1960), the hybrids were all sterile when tested by backcrossing, and almost all of them were males. The latter is an obvious example of Haldane's Rule.

However, unlike the *P. xuthus* crosses made by the two authors mentioned above, a small number of females were produced, which appeared quite normal until the time of eclosion and managed to rupture the pupal case, but could not go further.

At all stages the hybrids were intermediate between the two parents. Several features are noteworthy. The upper surface wing pattern of the hybrids for example resembled one parent while the under surface resembled the other. The presence of a hindwing tail was also intermediate between the two species. The hybrid larvæ, like the parents, showed two colour forms. Although most of the larval characters were intermediate between those of the two parent species in colour, one form resembled most closely the green form of *P. ægeus* while the other resembled the orange form of *P. fuscus*. In both forms however,

tubercles were present but smaller than in *P. ægeus*, and both forms also resembled that species in their willingness to accept certain foodplants. A further point of interest is the difference between specimens reared singly and those reared in a group in their ability to form the silk girdle for pupation. Whereas only one specimen out of the 13 reared singly pupated normally (Table 2), 22 out of 26 of those reared in a group formed the silk girdle and pupated normally. The difference is striking but its cause remains obscure.

A further feature of the hybrid larvæ was their resemblance to *P. fuscus* in the degree they were parasitized by tachinid flies. Whereas *P. ægeus* was heavily parasitized, *P. fuscus* was rarely attacked and the hybrid not at all. The eggs of the parasite, which are laid on the leaves of the foodplant, are ingested by the larvæ while feeding (Stride & Straatman, 1962). It may be that the degree of parasitization is correlated with the size of the mouthparts, the latter being greater in *P. ægeus* than in either *P. fuscus* or the hybrid.

SUMMARY

1. A female of *Papilio fuscus* was successfully paired with a male of *P. ægeus*, but attempts at reciprocal pairings failed.
2. Adult, but sterile, male offspring were produced, but of the females reared, none emerged from the pupæ unaided.
3. Larval and pupal characters were intermediate, and the larvæ showed two colour forms. Larvæ accepted several foodplants which were also accepted by *P. ægeus* but not by *P. fuscus*.
4. The hybrid adults had short hindwing tails and in pattern resembled *P. ægeus* on the upperside of the wings and *P. fuscus* on the underside.

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Doa Estate, Private Mailbag, Port Moresby, PAPUA

BUTTERFLIES AT LIGHT IN NORTH CAROLINA AND PENNSYLVANIA

Two male *Calycopis cecrops* were taken at powerful lights near Asheville, North Carolina, July 18, 1960. A male *Speyeria diana* was taken at the same place June 27, 1961. All were taken between midnight and 2:00 a.m. and were nearly perfect. A perfect male *Wallengrenia otho* was taken at blacklight in suburban Philadelphia, August 18, 1961, a cool misty night.

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