



黑斑病

The Black Spot Disease



↑ 身體各部位出現黑斑的三齡初期幼蟲。2006
Black spots on early L3 larva.

2002年正式回來台灣工作前，我把當時在美國養的長戟大兜全數送走。當時真的是有百般的不捨，好多隻都已經破百克了。回台灣工作後，由於工作真的相當繁忙，於是暫時告別了養蟲。但是過沒多久之後，我決定再忙也要再續前緣。畢竟，我也還沒達到養出170 mm的長戟之終極目標。由於長戟種源已經相當好取得，我很快地便從20隻二齡DHH中挑出了最有潛力的3公1母。為了能夠淋漓盡致地發揮這幾隻幼蟲的所有潛力，我給予牠們充足的食物及24度的溫控環境。往後的3個月，幼蟲的狀況相當良好，一切都在掌控及期望之中。看著這些完美無暇的肥美幼蟲，好幾次，我沾沾自喜，對自己自豪地說：「真不愧是沉醉兜鏹的作者，哇哈

After graduating from Vanderbilt University in 2001, I joined the work force and got unexpectedly busy. I decided to leave the beetles for a while. But what's in one's blood will always remain in one's blood. My beetle crave got resurrected when I walked by a beetle pet store in Taiwan and it was offering *D. hercules* larvae. I thought to myself: "I have yet to grow a 170-mm monster." Right there, right then, I was reconnected with beetles again. Of the 20 second instar larvae for sale, I picked the 3 males and 1 female that I thought had the most potential. In order to grow them to their maximum capacity, I gave them the best feed and a temperature-controlled environment. For the next three months, these larvae flourished. Looking at these flawless, fat larvae, I even said to myself: "I'm the man!" Little

哈」。但萬萬沒有想到，接下來，我將體會到「樂極生悲」的最真實感受。

由於腐植物在台灣已經相當容易大量取得，於是在十一月份的時候決定多養一些其他的長戟亞種，於是購入了4隻三齡初的DHO。當時的我可是在信心的最高峰，認為只要是出自我手調配出來的腐植土都是無懈可擊的。但也就是這個想法可能釀成了往後的夢魘！那一天，我到了屋頂的倉庫，發現了3大桶2年前養深山锹形蟲的廢土。在裡頭，我發現了許多當時提供成蟲爬行的硬朽木現在已經變成了很軟、很腐爛的腐木屑。這麼大量的腐木屑，叫我丟掉實在是覺得有點可惜。於是我便把它拿來和長戟大兜的食材混一混。完成後不管是顏色或是味道都讓我心花怒放，覺得這一定可以養出出色的大型個體。

起先這些腐植土先拿去給新買的4隻DHO吃。大約過了1個月以後我信心滿滿地要幫幼蟲換土了。電子磅秤當然也是準備好了，想說隨便也會增加個20幾克。就先從這隻公蟲開始吧。滿心期待又小心翼翼地把他倒出來。結果出現在我眼前的，不是一隻肥胖的幼蟲，而是連磅秤都不用使用就知道嚴重縮水的幼蟲！怎麼可能！真的，我不敢相信。接著趕緊把其他的3隻幼蟲也倒出來。這幾隻沒有縮水，但也沒有增重。我愣住了。真是百思不得其解。食材是之前測試過多年的成功配方，溫度、溼度也都沒錯。最後我只能歸咎於個體體質問題。

did I know that I was about to be struck with the biggest disaster of my beetle career.

Because high quality decayed vegetation can now be easily obtained in large quantities in Taiwan, I decided by November to keep more subspecies. I purchased 4 young third instar *D. h. occidentalis* larvae. I was at the peak of my confidence. Incidentally, on the same day, I found three buckets of deserted compost from two years ago when I was rearing *Lucanus* stag beetles in the attic. I thought it would be too much of a waste to simply throw it out and decided to mix it into the Hercules feed. This move might have planted the seed to disaster.

The mixed compost was offered to the 4 newly acquired *D. h. occidentalis* larvae. A month later, I was ready to do a substrate change and give them a weigh in. There was so much anticipation. I was sure they had each gained 20 plug grams easily. I thought I would start with a male. I dumped the larva out with care. But what was in front of my eyes shocked me. It wasn't an expected fat larva. There was no need for the scale either. Just with my naked eye, I could tell that he had shrunk! No way! I was dumbfounded. I quickly dumped out the other three larvae. Although they hadn't shrunk, they hadn't gained weight either. I was shocked. The temperature was perfect; the substrate was the same as I've always used; the humidity was normal. I thought and thought. At the end I could only make the conclusion that the larvae were just genetically unfit to begin with.



↗ 遭感染後嚴重縮水的三齡初期幼蟲。2006
Infected early L3 larva with severe weight loss.



↗ 身體各部位出現黑斑的三齡中期幼蟲。2006
Black spots on middle L3 larva.

大約再過2個星期，之前一隻成長速度驚人，頭殼16.5 mm、我最看好的DHE倒出來換土時，不但沒有增重反而縮了5公克。慌了，慌了，到底怎麼了？當天幫所有的幼蟲換完土後，4隻DHH、3隻DHE、2隻DHL，以及4隻DHO中，有2隻DHE、3隻DHO，以及1隻DHL變輕了。當時我並沒有想到會是傳染病，所以按照計畫地繼續購入了10隻L1的DHH。經過多方面的思考後，除了個體體質的可能性外，也開始懷疑兩年前的深山土是有問題的。也因此，最新進的10隻DHH所吃的食材都是另外準備，理論上是沒有受污染的。接下來的2個月，最新的這一批DHH都正常地生長。但是之前的4隻DHH、3隻DHE、2隻DHL，以及4隻DHO就沒這麼幸運了。這幾隻幼蟲全面停止增重，甚至已經有2隻DHE、1隻DHL，以及2隻DHO死亡。死亡的幼蟲行為上都有一個特徵，就是在一個地方窩著不動，一直

Two weeks later, a third instar male *D. h. ecuatorianus* larva previously recorded to have a shocking growth rate not only hadn't gained weight, but lost 5 grams. I was getting hysteric. I decided to check all the larvae. It was discovered that of my four *D. h. hercules*, three *D. h. ecuatorianus*, two *D. h. lichyi* and four *D. h. occidentalis*, two *D. h. ecuatorianus*, three *D. h. occidentalis*, and one *D. h. lichyi* had lost weight. I knew something was wrong for sure. But I hadn't thought of the possibility of an epidemic. As had planned, I purchased 10 more first instar *D. h. hercules* larvae. I thought about what I had done in the previous few weeks and started to suspect the two-year-old waste compost from the attic. Therefore, for the newly acquired larvae, I prepared a new batch of substrate for them. For the next two months, the new larvae grew normally. But for the earlier larvae, things went from bad to worse. They had all stopped gaining weight and two *D. h. ecuatorianus*, one *D. h. lichyi*, and two *D. h. occidentalis* had



到縮得很小然後死亡。外觀上，這些幼蟲的特徵是身體都出現大小、形狀不一的黑斑。這些斑點有些小至一粒沙、有些大至5 mm，形狀從圓形至不規則形都有。顏色從黑色、咖啡色、到黑色咖啡色混雜在一起都有。

由於新進的10隻DHH看起來都十分健康，我認為黑斑的問題已控制住，於是大膽地再購入8隻三齡初的DHT以及10隻三齡初的DHS。也大約在這個時候，家裡的蕈蠅（木蚋）大爆發，屋內滿天飛。雖然說我所有的幼蟲都分開飼養，但蕈蠅卻可以透過各個容器的透氣孔自由地進出。萬萬沒想到，平常沒有任何殺傷力，只是看了討厭的蕈蠅這下可能成為了間接殺手。

突然間，許多幼蟲都停止進食了，可以明顯地透過透明的容器看見牠們窩著不動。在檢查過所有40隻幼蟲後，發現每一隻或多或寡都長了黑斑，於是我暫時稱這種疾病為「黑斑病」。既然都遇到了，只好繼續養下去，看看能不能有幾隻撐到羽化。確定的是，這是一種傳染病，短期之內絕對不能再進新幼蟲。經過了接下來幾個月的觀察，發現感染這種傳染病的幼蟲會有以下A、B、C三種表現：

A：黑斑出現後不動 → 絕食 → 黑斑開始擴大 → 幾個星期後死亡。

B：黑斑出現後停止增重 → 正常進食 →

died. The five that died exhibited two symptoms before death: 1. They stopped moving about in the substrate. 2. Brown to black spots developed on their bodies. The spots ranged from 1 to 5 mm in diameter and were oval to irregular in shape.

As the newest ten *D. h. hercules* grew healthily, I was sure the disease was under control. As a result, I boldly purchased eight more *D. h. trinidadensis* and ten more *D. h. septentrionalis*. Yet fatefully, at around this time, fungus gnats had reproduced out of control off larval substrate and stock substrate. They were entering and exiting all the larval containers freely through the ventilation holes drilled on the covers. The gnats might have become the spreading agent for the black spot disease.

Suddenly, many larvae had stopped feeding. Through the clear containers, larvae could be seen motionless. Upon examination, all of the 40 plus larvae had developed the black spots and I temporarily called the disease “black spot disease.” It was a highly contagious disease. For the next few months, the larvae struggled. Three patterns were observed:

Pattern A: larvae developed black spots → larvae stopped feeding → black spots enlarged → death occurred.

Pattern B: larvae developed black spots → larvae stopped gaining weight but continued to feed → one day the larvae stopped feeding → black spots enlarged → death occurred a few weeks later.

Pattern C: larvae developed black spots →



↗身體各部位出現黑斑的三齡後期幼蟲。2006
Black spots on late L3 larva.



↗身體各部位出現黑斑的三齡後期幼蟲。2006
Black spots on late L3 larva.

突然有一天靜止不動 → 絕食 → 黑斑
開始擴大 → 幾個星期後死亡。

C：黑斑出現後停止增重 → 正常進食 →
最後成功化蛹、羽化。

到目前為止，我還沒遇過黑斑出現
以後還可以繼續增重的幼蟲。黑斑病爆
發時，幼蟲最高體重在80公克上下，分
別為3隻最初購入的DHH雄蟲，之後每
沉愈下，最後一隻於2006年12月死去，
體重掉到30公克，從發病到死亡牠撐了
整整一年，而牠也是這次黑斑病經驗中
最後死亡的幼蟲。絕大部分的幼蟲都在
發病後的1-3個月內死去。根據觀察，三
齡後期的幼蟲染病後的死亡率不高。三
齡初期的幼蟲染病後死亡率極高。整體
上而言，似乎是越後期感染黑斑病的幼
蟲越有機會存活。二齡幼蟲染病後通常
都能順利脫皮成為三齡幼蟲，並把黑斑
蛻掉，但不久後黑斑再現，然後拒食，
最後黑斑擴大死亡。

從最起先的幾隻個體病發黑斑病，
到41隻長戟幼蟲全部出現黑斑，只有短
短的3個月。值得一提的是，3個月的時

larvae stopped gaining weight but
continued to feed → larvae suc-
cessfully pupated and eclosed.

No larva was able to gain weight once
the characteristic black spots appeared. Most
larvae died within three months. When this
epidemic broke out, the heaviest larvae were
around 80 grams. They were the three *D. h.*
hercules males from the first batch. They
got successively worse. The last one died
in December of 2006 and his weight had
dropped to 30 grams. It took him fully one
year to wither and succumb to the disease.
He was also the last to die in this epidemic.
Death rate for middle L3 larvae and late L3
larvae was lower. Death rate for early L3
larvae was exceptionally high. The older the
larvae, the more likely they are to survive
the disease. L2 larvae were able to shed
the black spots during their molt to L3. Howev-
er, the black spots reappeared a few days to
a few weeks later. Death occurred not long
thereafter.

From the initial few larvae exhibiting
the black spots to all 41 larvae exhibiting the



↗從88克縮水到30克的幼蟲。2007
Larva that went from 88 g to 30 g.

間是出現黑斑症狀，但幼蟲很有可能更早之前就已經染病了。可以確定的是，黑斑病是一種傳染率以及死亡率極高的疾病。雖然說我每一隻幼蟲都分開飼養，但最後還是落到100%的傳染率。就目前看來，黑斑病的傳染模式可能至少有兩種：一是空氣孢子傳染，二是由其他動物帶菌傳染（以我的情形的話，就是滿天飛舞的蕈蠅了。）

但是黑斑病到底有多可怕？它是針對某些屬的幼蟲嗎？我很好奇，於是我拿了4隻二齡的綠島姬兜幼蟲來做實驗。這4隻幼蟲我群體飼養，並且唯一的食物來源為發病長戟幼蟲吃剩的腐植土。出乎意料地，這4隻幼蟲一路順利成長，於2006初夏全部羽化成大型個體，幼蟲時期身上沒有出現過一顆斑點。另外，我也同時期拿了2隻二齡的南洋大兜幼蟲做實驗，但養了幾個星期後，黑斑出現。雖然說脫皮為三齡時順利地將黑斑蛻去，但過不久後黑斑又出現，最後死亡。最誇張的是，由於家中飼有龍魚，因此在飼養長戟的房間內亦飼有麥皮蟲。麥皮蟲的生長環境和兜蟲幼蟲截



↗身體出現黑斑的麥皮蟲。2006
Super worm with black spots.

black spots only took three months. Worthy of note is the three-month period was the time for the later larvae to exhibit the black spots. Contraction of the disease might have occurred much earlier. What's for certain at this point is the black spot disease is highly virulent with a high mortality rate. Although I had kept all my larvae individually, every single one of them still came down with the disease. There are two possible ways for the transmittance of the black spot disease: one being air and the other being contact (in my case, it would be the fungus gnats).

I wanted to know how infectious the black spot disease was and if it was genus-specific. So I obtained four second instar *Xylotrupes gideon* larvae and fed them only used substrate from *hercules* larvae. Surprisingly, nothing happened. The larvae grow healthily and eclosed as major adults in early summer of 2006. Not one single black spot was observed on any of the larvae. At the same time, I also experimented with two second instar *Chalcosoma caucasus* larvae. Black spots occurred within weeks. The larvae were able to shed the spots upon molting to L3. But the spots oc-



然不同，前者生長於乾燥的介質中。但有一天，我發現了麥皮蟲身上也染上黑斑，並和長戟幼蟲一樣，出現了萎縮以及停止進食等症狀。雖然不能確定麥皮蟲染上的病原和長戟幼蟲的是同一種類，但這樣的巧合卻讓人心驚肉跳。

這一次的黑斑病經驗讓我付出了慘痛的代價。除了精神上的打擊之外，也有相當程度的金錢損失。當時為了提供幼蟲最完美的環境，冷氣24小時地放送，並於冬天時購買了電暖爐，一樣是24小時地運轉。在幼蟲發病之後，我對我自己做了最嚴格的要求。平常每過幾天便會去晃晃的蟲店我不再造訪，也不再去蟲友的住家，通通改為電話聯絡。若有事務非得見面，也一定是約在外面，並且洗頭洗澡後我才赴約。我也停止所有對外的幼蟲交流。停止所有的動作，就是深怕把可怕的黑斑病傳播出去。

雖然這一次的經驗是慘痛的，但也非無可取之處。我應該慶幸，黑斑病爆發在只有飼養41隻幼蟲的情況下，而不是400隻或是4,000隻，否則用欲哭無淚來形容都還不夠貼切。

在這一次的浩劫中，最後只有3隻DHH雌蟲化蛹，其中一隻化蛹不全，幾天後便死亡。這一隻個體生前黑斑有滲入體內的情況，導致於前蛹期時，蛹為了能夠脫離黑斑於是在距離表皮有一段距離的深處進行蛹體的形成，而在舊皮及蛹體之間則為大量的液體，讓整隻前蛹猶如一顆大水泡，相當不尋常。化



身體出現黑斑的三齡朱戴克斯歐洲深山锹形蟲幼蟲。2007

L3 *Lucanus cervus judaicus* with black spots.

curred weeks later and the larvae perished. Most amazing was I had kept some super worms as fish food in the same room with the larvae. These worms were kept in a near-dry environment. Yet one of the worms exhibited the black spots. Although there was no telling if the spots on the super worm and those on the rhinoceros beetle larvae were caused by the same disease, the discovery was nerve-wrecking.

The black spot disease cost me gravely, both financially and spiritually. In order to provide the larvae with the best growing environment, I had my home temperature controlled 24 hours: AC during the summer and heat during the winter. After the black spot disease broke out, I no longer visited beetle shops. Nor do I visit friends who rear beetles. If there was a need, we always met at a third location and I made sure to thoroughly shower myself before the appointment. I also stopped trading beetles



山嶽形蟲幼

black spots.

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因黑斑病死亡的三齡朱戴克斯歐洲深山嶽形蟲幼蟲。2007

L3 *Lucanus cervus judaicus* killed by black spot disease.

蛹之後蛹體疑似嚴重脫水，即使幾個小時之後仍然猶如洩氣氣球一般。另外2隻，有1隻因為人為疏失，羽化失敗，幾天後死亡（人工蛹室做得不夠好，導致新成蟲羽化後翻倒，翅鞘壓損）。最後一隻生還者於2006年的十二月八號羽化，2007年的一月十八號開始活動。二月七號的時候跟一隻外借的DHH雄蟲交配。二月十號的時候放入產卵箱，但是沒有想到這隻雌蟲竟然在二月十八號就死亡。三月二十八號收成幼蟲，但是只採收到5顆爛蛋。

黑斑病到底可不可以治療？經過了一番搜尋後，得知蛇類和蠍子的身上也會感染外觀相同的黑斑。在牠們身上，這種情形被稱為「霉斑病」，偶爾會大規模發生在中國大陸的養蠍場及養蛇場。文獻指出，霉斑病是各種掠食性

completely. I was deeply fearful of spreading the black spot disease.

Although the experience was a so-farful one, I had learnt to be a positive thing. I should consider myself fortunate that the black spot disease broke out when I only had 4 larvae, not 400 or 4,000.

In this epidemic, only three *D. h. cules* female larvae made it to pupation. One of them died a few days later. For this individual, the black spots had grown into her body while she was still a larva. During the pre-pupa stage, as a way to avoid the black spots, the pupa formed far away from the larval skin. As a result, the space between the pupa and the larval skin contained a lot of liquid. The entire pre-pupa appeared to be a big blister. After pupation, the pupa seemed dehydrated, as it remained flat and wrinkled. Another died a few days after eclosion due to human errors (the artificial pupal cell wasn't properly made and the adult tumbled over and damaged its back). The last one eclosed on December 8th, 2006. She became active on January 18th, 2007. She mated on February 7th and placed in the breeding tank on the 10th. Surprisingly, she died eight days later. The substrate was checked for larvae on March 28th, but only five rotten eggs were found.

Can the black spot disease be treated? After some research, it was discovered that similar black spots also occur on snakes and scorpions and they are caused by predatory fungi. Affected snakes and scorpions can be treated by having iodine rubbed on affected areas twice a day. If not treated, affected animals



真菌造成的。治療霉斑病的方式之一是擦拭碘酒，並且早晚各一次。若不積極地治療，染病的蛇蠍難逃死亡的命運。資料也指出，保持養殖場的乾燥能夠有效地控制疫情。但是這裡出現了三個問題。第一，黑斑病是否就是霉斑病？第二，即使是，幼蟲是極度怕干擾的生物，從來就沒有飼養者天天換飼料，更遑論一天把牠們挖出來兩次擦拭碘酒。不但如此，根據我的觀察，幼蟲身上的黑斑不只出現在表面，有些斑點亦會滲入皮膚深處，因此擦拭碘酒的療效在幼蟲上應該是相當有限。第三，要把幼蟲養在完全乾燥的環境是不可能的。我嘗試過把幼蟲的腐植土溼度降低，但如此並未阻止黑斑擴散。這一次的經驗告訴我，黑斑病對幼蟲可以說是絕症。也因此，預防比什麼都要來得重要。經過仔細地回想之後，我歸類出這次黑斑病爆發的可能途徑：

1. 空氣傳染
2. 病發前我觸碰每一隻幼蟲時都未洗手，但是此時可能已有幼蟲感染，導致病原擴散。
3. 病發前所有的幼蟲共用一個篩食物的濾網，導致病原擴散。
4. 病發前所有的幼蟲共用一個裝飾剩食材的容器，導致交叉感染。
5. 蕈蠅、蟑螂仔於各容器間竄梭，傳播病原。

只要黑斑病非空氣傳播，對於黑斑病的預防，最有效的方式應為以下數點：

likely to die. It was pointed out that a dry environment can prevent the disease from spreading. However, three problems are encountered. One, is the black spot disease caused by fungi? Two, even if it was, as sensitive as larvae are to disturbance, they cannot be dug out twice to have iodine applied. Furthermore, black spots do not occur only on the surface. The effectiveness of iodine application is probably limited in treating larvae. Third, it's not possible to keep larvae in a dry environment. I have tried lowering humidity of substrate, but this didn't stop the disease from spreading. It appears the black spot disease is a dead-end street for beetle larvae. As a result, prevention is key. After some analysis, I came up with five possible ways of transmittance:

1. By air.
2. I handled all the larvae with my bare hand and I did not wash my hands in between larvae. Some larvae might have already been infected but not yet showing symptoms.
3. All the larvae shared one substrate filter and it was not washed between use.
4. All the larvae shared one filtered substrate holder and it was not washed between use.
5. Fungus gnats and cockroach nymphs were entering and leaving all the rearing containers freely.

As long as the black spot disease is not transmitted through air, the following mea-

1. 所有幼蟲單獨飼養 (或是已混養的幼蟲切勿再和其他批幼蟲接觸)，透氣孔確實做到用細紗網杜絕任何昆蟲的入侵，尤其是蕈蠅和蟑螂仔。
2. 廢土和新鮮食材不要交叉感染 (A幼蟲的廢土和新鮮食材接觸後又餵給B幼蟲)。
3. 過於老舊的食材不要使用 (不要硬是要省錢，有時真的因小失大)。
4. 每觸碰完一隻幼蟲後，務必先徹底洗手才可觸碰下一隻幼蟲 (有些飼養者甚至不用手直接觸碰用蟲，一率使用湯匙或是手套。畢竟，人類的手本身就帶有很多細菌)。

不過說來也很奇怪，早在十幾年前就發現幼蟲身上三不五時會出現非咬傷所導致的黑斑，也在「沉醉兜鍬」第一版中的第309頁提到，幼蟲身上偶爾會出現不明的黑斑，但當時那些黑斑從未惡化到幼蟲絕食，更別說是死亡的地步。本書第79頁的美西白兜幼蟲以及231頁的大王花金龜幼蟲身上也都有黑斑，但是在2000年時也都順利羽化。黑斑病是不是不只一種？黑斑病病原是不是只有在特定的環境下才會發病？黑斑病背後到底是什麼樣的生物在作怪？於是，我決定把冷凍庫裡的幼蟲拿去做專業病理分析。

首先我將高解析度的圖檔e-mail給國立台灣大學的昆蟲病理學權威王重雄教授。王教授看了照片後表示，病原有可能是真菌、細菌、病毒，或是線蟲。確切的診斷需要透過分析幼蟲的血淋巴

sure should suffice in keeping it contained:

1. Keep all larvae individually (larvae already kept in groups should not come in contact with larvae from other groups) and make sure all the ventilation holes on the containers are meshed to prevent entrance of unwanted pests such as fungus gnats and small cockroaches.
2. Waste substrate and stock substrate should never cross contaminate (for example, waste from larva A comes in contact with the stock substrate and the stock substrate is then fed to larva B).
3. Avoid moist substrate more than 8 months old.
4. Wash hands (or tools) thoroughly before handling any larva (some breeders even wear gloves or use spoons as the human hand is full of bacteria).

The black spot disease is a mysterious one. I remember having seen black spots on larvae as early as over a decade ago. And those spots weren't caused by wounds. In fact, it was mentioned in the first edition that larvae occasionally exhibit black spots for unknown reasons. However, the black spots never caused any death then. The *Dynastes granti* larva on page 79 and *Goliathus goliatus* larva on page 231 have the characteristic black spots on them. Yet those larvae eclosed safely in 2000. Could there be more than one kind of spot-causing disease? Could the black spot disease be fatal only under certain circumstances? What is the black spot disease? I decided to take my frozen larvae to an insect pathology lab.



才能夠完成。

在此同時，我也學習到了重要的新知識。那就是身體出現黑斑是昆蟲的免疫反應之一。根據了解，黑斑的成分是黑色素。由於黑色素能夠抑制真菌的生長，因此當昆蟲的身體遭受外來物入侵時，免疫系統就會開始在入侵處形成黑斑。換句話說，黑斑並不是病原直接造成的。在這裡我們必須做一項更正。那就是「黑斑病」不是病，而是昆蟲的免疫機制。當昆蟲身體出現黑斑時，我們只能夠下一個定論。那就是昆蟲遭到攻擊了，但是入侵者是誰就必須透過化驗才能夠得知。如果黑斑面積很小，而之後也不再擴大，幼蟲已經成功阻止了外來物的入侵。如果黑斑不停擴大，表示黑色素不是敵人的對手，幼蟲的未來凶多吉少。這也解釋了為什麼十多年前出現小黑斑的幼蟲都成功羽化了。此外，我們也懷疑，當時攻擊幼蟲的病原和這一次的病原是完全不同的物種。

如果幼蟲身上不幸出現黑斑，立刻做以下四個動作：

1. 用自來水把幼蟲沖乾淨。
2. 用別的容器和新的腐植物飼養幼蟲。
3. 把舊的腐植物全部丟棄。
4. 舊容器洗淨後用5%濃度漂白水浸泡24小時殺菌。

至於幼蟲能不能戰勝病原體，就要看幼蟲自己的造化了。

經過王重雄教授親自化驗後，鑑定幼蟲感染的是*Adelina*屬的孢子蟲。這

I first sent high-resolution images to Dr. Wang Chung-hsiung of National Taiwan University, who is an expert in insect pathology. After reviewing the photographs, he expressed that the pathogen could be fungus, bacterium, virus, or nematode. A definitive diagnosis would require thorough analysis of larvae's hemolymph.

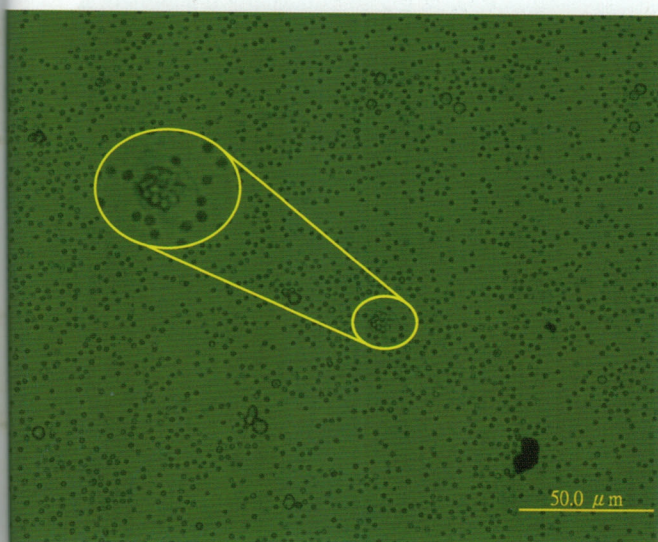
In the meantime, I had also learnt important new information. As it turned out, developing black spots is an immune response of insects. Black spots are a result of melanin aggregation. Because melanin can suppress fungal growth, the immune system forms black spots where skin is attacked. In other words, pathogens do not directly cause black spots. As a result, the “black spot disease” is really not a disease, but an immune response. When black spots form on an insect, we can only say that it is under attack, but the identity of the pathogen can only be revealed through lab analysis. If the black spots are small and remain so, the insect has successfully blocked the pathogen. If the spots continue to enlarge, melanin is no match for the attacker, and the larva is likely to perish. This explains why the larvae from a decade ago with small black spots all eclosed safely. Furthermore, we can make the assumption that the pathogen then was completely different from that of this outbreak.

If black spots occur on a larva, do the following immediately:

1. Wash larva with tap water.
2. Keep larva in a different container with new substrate.
3. Discard old substrate.
4. Soak old container in 5% bleach solution for 24 hours to disinfect.

是一種單細胞寄生蟲。感染源是蟑螂糞便。幼蟲吃入遭到蟑螂糞便污染的腐植物後，孢子蟲穿透幼蟲的腸壁進入脂肪體，然後成千上萬地繁殖。幼蟲免疫系統起反應，全身各處出現黑斑。孢子蟲再透過幼蟲的糞便擴散。孢子蟲的卵囊有一層厚壁保護，乾燥、冷凍，或是酒精都無法殺死。有效消毒液為5%濃度的漂白水或是福馬林。

幼蟲身體出現黑斑不代表感染了孢子蟲，但是如果化驗同批死亡幼蟲或是糞便後，確定是孢子蟲感染，建議的處理方式是把幼蟲冷凍後火化。即使幼蟲成功羽化，體內還是帶有孢子蟲。一旦放入繁殖箱，病原又會擴散開來。



← 送化驗的幼蟲脂肪體顯微照。照片中的所有顆粒都是孢子蟲。圈起部位為遭到孢子蟲入侵的細胞。照片王重雄教授團隊拍攝。2008

Sample of infected fat body tissue. All the dots are coccidia. Circled portion represents cell infected with coccidia. Photograph taken by Dr. Wang's team.

Then all the hobbyist can do is hope for the best.

After analysis by Dr. Wang Chung-hsiung's lab, the pathogen was identified as a coccidium of the Genus *Adelina*, a single-cell parasite. The source of infection is cockroach excrement. After a larva consumes contaminated substrate, the coccidium penetrates the larva's intestinal lining and enters the fat body tissue, in which it proliferates. The larva's immune response is triggered and black spots form. The coccidia spread through larval excrement. Oocysts of coccidia have a protective layer that is resistant to drought, freezing, and alcohol. Effective disinfectants include 5% bleach or formalin solution

Black spots do not signify contraction of coccidia. However, if dead larvae or excrement test positive for coccidia, all larvae should be frozen and cremated. Even if larvae successfully eclose, their body is still loaded with coccidia. If they are placed into the breeding tank, the disease organism will only spread.