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LIFE HISTORY OF *ISOPARCE CUPRESSI* (SPHINGIDAE)

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References to the life history of *Isoparce cupressi* (Boisduval), the Cypress Sphinx, are scarce in the literature. The only description of the larva known to the author is that by Bates (1928) referred to by Hodges (1971). The adult moth has been taken with regularity in coastal South Carolina at light in the neighborhood of its food plant, Bald Cypress (*Taxodium distichum* (L)). Two main broods occur in this area, the spring brood from mid-March through mid-May with a high peak in April, and the second brood predominately during August and September. A scattering of specimens is also taken during all the summer months. Hodges (1971) has given an excellent description of the adult moth, but one further distinctive feature should be mentioned. Just to the costal side of the heavier broken black dash on the forewing, at about the center of the wing surface, is a reddish brown streak running parallel with and adjacent to the black dash. This marking, together with the black dash (there are often two or three of the latter), is quite conspicuous and diagnostic in the fresh specimen.

On 13 August 1971 at McClellanville, South Carolina a female *Isoparce cupressi* was captured at a mercury vapor light, labelled ♀ A'71, and permitted to lay eggs in captivity. She did so without hesitation, laying approximately one hundred eggs, first on paper in a plastic box and later

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Color Plate. *Isoparce cupressi* (Bdv.) and its foodplant (*Taxodium distichum*) (natural size). 1. Adult ♂, caught at light 13 Sept. 1968; 2. 2nd instar larva, 5 days old; 3. 3rd instar larva, 11 days old; 4. 3rd instar larva, 10 days old; 5. 4th instar larva, 13 days old; 6. 4th instar larva, 14 days old; 7. 5th instar larva, 3 weeks old, full grown; 8. pupa, 1 week old, ex larva placed on wild cypress tree; 9. and 10. 5th instar larvae, 3 weeks old, full grown; 11. 5th instar larva, 3 weeks old, about to pupate. (All larvae are freeze-dried specimens.)

on sprigs of cypress introduced for her benefit. Being confined to a small area, of course, a natural pattern of egg-laying could not be definitely determined; however the eggs were laid singly rather than in clusters, and when the fresh cypress was presented she chose to lay singly on the plant. The eggs are slightly flattened spheres 1 mm in diameter, grossly smooth, microscopically very slightly and evenly roughened, and of a pearly green color. The micropyle appears to lie dorsolaterally. The larva hatches in seven days, leaving a transparent uneaten eggshell. We killed our female after three days. No food was presented as it is a superfluous commodity for a moth with rudimentary mouthparts.

Larval Instars

Coloration and markings of the larvae through the successive instars progress as a model of camouflage on their food plant. The first instar larva is green and at one day old is about 3 to 4 mm in length, with a black dorsal horn about 3 mm long. The head is round, green and immaculate. A dorsal and two lateral stripes, one on each side, extend the length of the caterpillar except for the prothoracic segment where they fade toward the head. These three stripes are of a slightly darker green. Very thin paler bands run transversely over the dorsal surface from one lateral stripe to the other, marking off the segments. The result is a tiny larva just about the size of one of the pinnae of the young shoots of the cypress, and the larval variation of greens blends beautifully with a lengthwise position on one of the leaflets.

The second instar occurs about four days later and the larva grows to about 10 mm in length. The basic body color is a forest green, while the head acquires a pair of yellowish-green vertical stripes down each side and a similar but thinner pair down the center line. These stripes diverge somewhat from the top of the head where they commence at the base of a pair of tiny hornlike protuberances. On all segments of the body a dorsolateral and a vertrolateral stripe of a yellowish cast develop, these stripes becoming slightly constricted at the juncture of the segments and just beginning to show signs of segmental angling posteriorly toward the median. The first thoracic segment resembles the top of the head in tending to define a rather sharp angle dorsally. At this stage the first whitish lateral lunules appear, running obliquely posterodorsally from the mesothoracic segment to and including the seventh abdominal segment. On the prothoracic segment, the lunule is replaced by a horizontal white dash which continues posteriorly, fading and connecting the tops of the successive lunules. On the first thoracic segment it remains a distinctive mark throughout the succeeding instars. The horn, on the eighth ab-

dominal segment, has a roughened surface, a touch of red to its predominately black color, and is about 4 mm in length.

The third instar occurs in about another four days. For that matter, four or five days proved to be the average for each of the stadia. The pattern of the head shows no significant change. The stripes on the body remain in the same general pattern, but the longitudinal yellowish stripes are now more broken with each segment; the dorsolateral pair assume a slightly oblique aspect on each segment, slanting even more toward the median posteriorly. At this time a reddish spot appears at the site of the spiracle on each segment except for the second and third thoracic segments. The second thoracic spiracle shows instead a small black spot with one or two tiny white punctae, and that of the metathoracic segment tends to be featureless. The junction of the lateral oblique lunules (which are now acquiring the yellowish tinge of the other markings) and the ventrolateral broken stripes is now forming the shape of an arrowhead pointing cephalad on each segment, with the colored spiracular dot at the point of the arrow. It is during this third instar that the forest green of the dorsal surface begins to change to a red-brown (later darkening to a purple-brown) dorsal stripe that is a conspicuous character of the larva from this period on. It characterizes a camouflage consistent with the growth stage when the larva travels by way of the brown twigs of the cypress, and this stripe down the back with the oblique yellow-white markings on the green base color assumes the pattern of light through the foliage. This dark dorsal stripe begins on about the mesothorax and extends posteriorly onto the horn. The larva is also just beginning to show signs of developing the tiny yellow punctae that will appear more markedly later on, adding to the broken-light pattern. These spots first appear anteriorly. At the end of this instar the larva is about 18 mm long, and the posterior horn recurves slightly. The thoracic legs also gradually change color from green to reddish brown as the larva grows.

The fourth instar begins roughly two weeks after hatching. The head acquires a pair of black lines diverging downward from the upper pointed "horns" and ending about two-thirds of the way down the face. All the prolegs, including the anal, now acquire the red-brown color of the spiracles. The metathoracic spiracle may or may not have a reddish punctum; if so, it remains less conspicuous than the others. The small yellowish punctate excrescences now appear on all body surfaces. The yellowish ventrolateral segmental markings are by now well broken up by segments, and tend to disappear from the second thoracic to a variable number of segments between the mesothoracic and anterior abdominal segments. The dorsal markings are now more purplish-brown and are

punctuated by rows of minute whitish dots, while the spiracular color remains reddish as does the base and dorsum of the horn. The horn is now beset with spicules. The dorsal brown stripe takes on a newly developing shape. Beginning with the mesothorax the purplish brown of each segment has the shape of a half hourglass with the thin end behind. This is laterally edged by a touch of black and in turn with the remains of the broken yellowish dorsolateral stripe. The first thoracic segment follows the general pattern but presents a different appearance because the dorsal brown, having disappeared here, is replaced by a thin black mark flanked by the yellow and in turn by a pair of new black spots, flanked yet again by the yellow line first seen in the second instar which is in reality the lateral lunule pointing anteroposteriorly. By the end of the fourth instar the larva has reached a length of about 3 cm or slightly less. One freeze-dried specimen (not illustrated) just shedding into the fifth instar is marked as being 16 days old.

The fifth instar larva continues rapid growth to a length of about 5 cm, with the posterior horn measuring slightly under 1 cm. The abdominal spiracles and the dorsolateral surface of the prolegs become partially dark brown to blackish; the second thoracic spiracle tends to maintain its dark color with white punctae; and the rest of the spiracular coloration assumes some black along with the red-brown, that of the metathorax tending to remain relatively modest. The yellow punctate excrescences have become more numerous, following to some extent the direction of the yellow lines and lunules. These latter acquire traces of brown or black edgings. Posterior to the eighth abdominal segment (i.e., abaft the horn), the lateral spiracular brown ceases and the yellow lateral lunule straightens out to run posteriorly down and across the anal plate where it meets its mate. Some of these lines and lunules may be more white than yellow. The anal plate is greyish green dotted with tiny black spots. All in all we have an extremely handsome caterpillar, camouflaged in such a way as to be very difficult to detect on a wild cypress.

According to Bates (1928) the larvae feed at night. I was able neither to confirm nor deny this observation since this brood from ♀ A'71 was reared in confined and therefore artificial quarters and demonstrated no meal-time preferences.

Pupating Habits

At the end of approximately three weeks the larvae turn a purplish brown color all over and begin to wander in preparation for pupation. This color suits them well for travelling more openly on the larger branches and trunk of the tree. Their pupating habits, being for all practical purposes unknown, were of especial interest, and I endeavored

to simulate natural conditions as well as possible with some interesting, and at times perplexing and amusing results.

Three sets of conditions seemed indicated in order to discover the actions of a *cupressi* larva seeking to pupate. First was the simulation of a cypress tree standing in the water, described herein as the "water cage." Second, the simulation of a cypress growing on dry land, described as the "ground cage." Third, taking a larva directly out to a wild cypress pond and hoping for the best.

The "water cage" was made by cutting a cypress branch about two feet long and 2½ inches in diameter and suspending it by a thread from the top of a cage with its bottom end submerged in a can of water. Such a branch is quite smooth, and in order to create the likeness of a crevice or two, a couple of branching twigs were tied to the side of the limb. A smear of vaseline was applied to the suspending thread to discourage the caterpillar from climbing off the wood. The "ground cage" was made by filling a large coffee can with fine sand covered with a couple of inches of peat moss, and a similar-sized cypress branch with twigs was stuck upright into the center of the can. Vaseline was smeared around the edges of the can to discourage wandering out of the allotted area. In all, seven pupating *cupressi* larvae were used, six in the cages and one reserved for the wild.

Larva #1, on 12 September, was placed on the bark of the "water cage." It climbed up and down the eighteen inches or so of available dry trunk several times, being turned at the top by the vaseline on the thread and at the bottom by the water. It was not averse, however, to dunking its head quite thoroughly into the water before turning back. After a while it began to settle into one of the slight crevices provided by a twig, but after an hour or so of trying to snuggle in was evidently not satisfied and wandered off again, whereupon it fell into the water and drowned.

Larva #2 on the same date was put on the cypress in the "ground cage." This one was observed for twenty minutes or so crawling all about the "tree trunk" and then curled up on the top of the stump and to all appearances took a nap. At this point I was called away for about ten minutes, and upon my return there was no sign of the larva. There was no possible route of escape from the cage, and subsequent investigation proved that it had descended the "tree" and burrowed underground where it proceeded to pupate.

The next day, 13 September, three more larvae were ready to pupate. Larva #3 was put in the "water cage" and it wasted very little time indeed before either crawling or falling into the water when I had my head turned for just a moment. This time rescue was prompt, and the cater-

Fig. 1. The author points to spot where larva #7 pupated. Photo by C. R. Edwards, 26 Sept. 1971.

pillar was put into the "ground cage," where it immediately crawled down the trunk and burrowed straight into the peat moss. Larvae #s 4 and 5 were then put directly into the "ground cage," and neither spent more than fifteen or twenty minutes before burrowing underground. The sand of course in this cage was packed tightly enough to support the cypress limb firmly, and the peat was fairly loose on top, but an average of only thirty seconds was required for each larva to disappear completely.

Since the "water cage" seemed a fatal hazard, I then compromised and replaced the water with sand and peat, inserting the trunk in a manner similar to the "ground cage," but in this case greasing the bottom two inches of exposed trunk with vaseline, hoping to discourage headlong downward progress but providing a safe landing just in case. Caterpillar #6 was then put on the trunk and was observed to head downward, hardly hesitating at the greased bottom. Crawling right over the vaseline, it too disappeared rapidly underground. One week later I carefully spooned out the peat and sand and found #6 had pupated in a slightly packed chamber about three inches below the surface, in the sand. There was no evident sign of silk spinning.

Larva #7 was ready to pupate on 15 September. This was the one

reserved for the wild, and was taken to a nearby cypress pond. A smallish cypress about a foot or two in diameter that was standing in the water having been selected, the larva was placed on the trunk about breast high and left to its own devices. A smallish tree such as this has relatively smooth bark, and this particular tree was chosen for a relative paucity of crannies, moss or other hiding places. This larva crawled all about and twice tried to dig into some small patches of moss, but it was evident they did not offer the protection it desired. After an hour or so of being left to explore this tree, it was transferred to a neighboring tree which offered greater chances of concealment by way of crevices and heavier patches of moss. It was interesting to note a determined attempt on the part of the larva to burrow into one mossy niche which was almost but not quite deep enough to hide it completely. The power of forcing its way into tight corners and under quite thickly rooted moss, and its evident strong desire to burrow, were noteworthy. After a half hour's attempt the caterpillar gave up and went off in search of a better spot. It found one to its satisfaction a short distance away in a patch of moss thick and deep enough to permit its burying itself completely out of sight. I marked the spot and returned a week later, and then carefully peeling back the moss, found the pupa deep in a mossy cell, smoothly shaped but again with little or no appreciable sign of spinning (Fig. 1).

These observations would seem to indicate a strong burrowing instinct on the part of the pupating *cupressi* larvae, and would explain the great difficulty of successfully searching for pupae in the wild, but will perhaps give an indication of where and how to look. The two cases of larvae falling into the water reported here can possibly be best explained by the artificial conditions imposed with insufficient room for manoeuver.

Hodges (1971) mentioned two *cupressi* pupae found by this author the previous year. These were in fact found in a remarkable and unique tract of very old virgin cypress, of the type known to the lumber industry as "Black Cypress" and noted for its fine quality. It is a tract of swampland known as Four Holes Swamp, consisting of less than 3000 acres of uncut timber near Summerville, South Carolina. It is one of the last two tracts of such trees left in the Southeast, and an urgent conservation measure is under way in an attempt to save this remnant of the past where the trees are several hundred years old and some measure over ten feet in diameter above the massive buttress. Great shards of bark hang loosely from the towering trunks, and a day's canoeing through this magnificent primeval swampland forest is an experience to stir the blood. Brown water snakes and alligators abound, or an otter may be seen gazing with inquisitive whiskers aslant before gliding silently under the dark waters. A full day of examination of every cypress within reach produced the two pupae, mentioned by Hodges, tucked under the protection of loosely hanging bark. As with those reared, neither pupa of that day showed any indication of having spun.

Of the reared brood of larvae ex ♀ A'71, a goodly number were preserved in the various instars by the technique of freeze-drying, some of

which are shown in the illustration. Two of the six pupae (remember one larva drowned) were likewise preserved whole, and four adult *cupressi* moths emerged under indoor conditions in early October. The pupal cases of these latter were unearthed from the sand in the cages, and were all found at approximately the same depth and in the same type of cells as mentioned above.

The pupa is dark brown, about 3.5 cm in length and on the moderately slender side. It lacks a free tongue case. Its surface is punctate on all sides, though ventrally the abdominal segments are smooth posteriorly. It should be noted in passing that while our pupae agree in description with that given by Bates (1928) except for the placement of the punctae, none of our reared larvae reached the length quoted by that authority of 65 mm, though the four emerging adults were of normal size.

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BEHAVIORAL ADAPTATIONS OF CRYPTIC MOTHS. VI. FURTHER EXPERIMENTAL STUDIES ON BARK-LIKE SPECIES

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Prior studies have demonstrated that a number of bark-like moths will select appropriate backgrounds in various experimental apparatuses which provide a choice of backgrounds differing in reflectance (Kettlewell, 1955; Sargent, 1966; Sargent & Keiper, 1969). Several experiments indicate that these selections are based on innate preferences of the moths for certain background reflectances (Sargent, 1968, 1969a, b).

The present paper summarizes additional experiments which shed light on (1) some factors promoting "errors" in the background selections of


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