Journal of the Lepidopterists' Society
62(2), 2008, 80–83

NOTES ON *PAPILIO MACHAON ALIASKA* (PAPILIONIDAE) POPULATIONS NEAR FAIRBANKS, AK

SHANNON M. MURPHY

Department of Ecology and Evolutionary Biology, Corson Hall, Cornell University, Ithaca, NY 14853, USA; Present Address: Department of Biological Sciences, The George Washington University, Lisner Hall, Suite 340, 2023 G Street, NW, Washington, DC 20052, USA;
email: smurph@gwu.edu

ABSTRACT. I present results from a mark-recapture study of *Papilio machaon aliaska* swallowtail butterflies from four sites near Fairbanks, Alaska. The sites were alpine-tundra hilltops and butterflies were caught throughout the month of June in 2000–2003. Only males (n=569) were marked and released while females (n=31) were kept for other experiments. Adult males tended to fly earlier in the season than did females and also were found flying earlier in the day than females. About one sixth of the males that were marked were later recaught and some were caught multiple times (up to six times for one male). Most males were recaught within four days of their initial catch date, but a few were caught many days later. Thus, these data indicate that some males may live for up to two to three weeks under natural field conditions. The research presented here support the claim that *P. m. aliaska* is a hilltopping swallowtail butterfly.

Additional key words: flight behavior, flight times, mark-recapture.

Swallowtail butterflies from the *Papilio machaon* group use plants of the Apiaceae as their primary hosts (Feeny *et al*. 1983; Sperling 1987; Thompson 1995; Wiklund 1981). Apart from occasional use of plants in the family Rutaceae, an ancestral host family for the genus *Papilio* (Sperling 1987), *P. machaon* swallowtails have rarely incorporated non-apiaceous plants into their diet. In Alaska and northwestern Canada, *Papilio machaon aliaska* Scud. oviposits and feeds not only on the local apiaceous host, *Cnidium cnidiifolium* (Turcz.) Schischk., but also on *Artemisia arctica* Less. and *Petasites frigidus* (L.) Franch. (Scott 1986) in the Asteraceae. This host-range expansion by *P. m. aliaska* appears to represent an intermediate step towards a complete host shift.

Previous work has demonstrated that shared chemical cues in ancestral and novel host plants may have provided the opportunity for the establishment of the host expansion onto the two novel host species (Murphy & Feeny 2006). However, these host plants are not equal in terms of larval survival in the field (Murphy 2004) or the laboratory (Murphy 2007a). In the absence of predators, *P. m. aliaska* larvae survive best on the ancestral host plant, *C. cnidiifolium*, but in the presence of predators, larval survival is greater on the novel host plants. In the field, the novel host plants seem to offer larvae enemy-free space that is not found on the ancestral host plant simply because of their different local environments. Predators are common in the ancestral host plant's environment and larval mortality on *C. cnidiifolium* can be very high in the field; enemy-free space on the novel host plants may be the selective pressure maintaining the host expansion, possibly driving the incipient host shift to completion.

Despite the environmental differences and physical distance between the locations where the larval host plants can be found, *P. m. aliaska* is thought to be a typical hilltopping swallowtail butterfly (cf. Lederhouse 1982; Shields 1967). Hilltopping is a widespread behavior in butterflies and has been documented in at least five Lepidoptera families, including Papilionidae (Shields 1967). When males and virgin females emerge from their pupae, they fly towards a local topographic prominence (Pe'er *et al*. 2004), which may be quite minor in appearance (Baughman & Murphy 1988), and congregate at the summit. Hilltopping behavior may be an effective method for finding mates in low-density species (Scott 1968) or in species that do not mate on or near their larval host plants (Rutowski 1991). Males tend to establish territories (or 'perches' *sensu* Scott 1974) and exhibit aggressive behaviors towards other males as well as other butterfly species (Lederhouse 1982). Virgin females, or females that mate multiple times in some species, also summit the hilltop, mate with the males, and then return to lower elevations to search for oviposition sites (Shields 1967, but see Pe'er (2004) for a discussion of whether this downhill movement is active or passive). Thus, on these hilltops, males tend to be numerically more common than are females since females only summit long enough to mate while males defend their territories and wait for new mates at the top of the hill (Alcock 1985; Shields 1967). Lederhouse (1982) found that for the black swallowtail butterfly, *Papilio polyxenes*, early-emerging males were more likely to defend a preferred territory, and these preferred territories were visited more frequently by females.

Here I present data that I gathered when I was collecting *P. m. aliaska* individuals in the field, including a mark-recapture study on *P. m. aliaska* males. The goal of this research is to investigate the flight behaviors of *P. m. aliaska* butterflies in the field. In addition to learning

more about peak flight time and longevity under natural conditions, I aimed to determine if my observations of *P. m. aliaska* flight behavior near Fairbanks, AK are consistent with patterns associated with other hilltopping butterflies (e.g. female rarity and males that either remain or return to a hilltop regularly for several days).

Materials and Methods

With help from many field assistants, I collected *P. m. aliaska* individuals from four sites in Alaska. The sites were alpine-tundra hilltops (domes) near Fairbanks, AK: Ester Dome (64°52'N, 148°4'W, ~720m), Murphy Dome (64°57'N, 148°21'W, ~890m), Wickersham Dome (65°13' N, 148°3' W, ~977m) and along the Pinnel Mountain trail southwest of Table Mountain (65°25' N, 145°57' W, ~1,200m). The two closest sites, Ester and Murphy domes, are about 18 km apart while the two sites that are farthest from each other are about 120 km apart (Ester and Pinnel Mountain). These four sites have populations of the host plants *Artemisia arctica* and *Petasites frigidus* and vegetation characteristic of open tundra. Ester and Murphy Domes are characterized by low birch and willow scrub (*Betula, Salix* spp.) with a few small spruces (*Picea*) as well as dwarf scrub (*Andromeda, Anemone, Carex, Empetrum, Epilobium, Ledum, Lupinus, Pedicularis, Petasites, Pyrola, Salix, Vaccinium, Valariana*). The Pinnel Mountain trail and Wickersham Dome are more open, without any trees on the tops of the domes, and the terrain is covered by the dwarf scrub described above.

In 2000 I was the only person in the field collecting butterflies. In 2001 and 2002, however, I had a field assistant so the number of butterflies caught reflects the efforts of two people. During these two field seasons I would often drop my assistant off at one dome and then I would travel to another dome. We were thus sampling two sites per day, each with the effort of a single person. In 2003 I had two field assistants, but this year we all sampled a single site together. We spread out and were able to sample each site more extensively. During each field season, we began searching for butterflies by May 25 and continued searching for flying adults until early July. All butterflies that were caught were marked and numbered (see Carter & Feeny 1985) and during the 2001, 2002 and 2003 field seasons the time of day that the butterflies were caught was also recorded. Females were kept for experiments. Most males were released at the end of the day although some were kept overnight so that we could mate them with the females. The males that were kept were released within a day or two and always at the same field site.

Sampling effort varied by site; the sites that were closer to Fairbanks (Ester Dome and Murphy Dome) were sampled more frequently than the sites that were more distant (Pinnel Mountain and Wickersham Dome). Ester Dome was sampled a total of 25 days (5 days in 2000, 6 days in 2001, 8 days in 2002 and 6 days in 2003). Murphy Dome was sampled a total of 18 days (4 days in 2000, 4 days in 2001, 6 days in 2002 and 4 days in 2003). Pinnel Mountain was sampled a total of 6 days (3 days in 2000, 2 days in 2001 and 1 day in 2003). Wickersham Dome was sampled a total of 11 days (4 days in 2000, 4 days in 2001, 1 day in 2002 and 2 days in

Table 1. Number of male and female *P. m. aliaska* individuals collected at each field site during each year of the study.

	Site				
Year	Ester Dome	Murphy Dome	Pinnel Mtn	Wickersham Dome	Totals
Females					
2000	1		2	4	7
2001	4	2	3	1	10
2002		2			2
2003	6	1		5	12
Totals	11	5	5	10	**31**
Males					
2000	14	62	26	23	125
2001	26	22	27	49	124
2002	53	71		34	158
2003	32	76	7	47	162
Totals	125	231	60	153	**569**

2003). The sites were visited more frequently than the number of days given above, but only days in which butterflies were actually caught are counted in the tallies.

RESULTS AND DISCUSSION

Males were plentiful and easy to find and catch. During the four years of data presented here, we caught 569 males (Table 1). Males were often observed circling an object (a bush, rock or piece of debris) as well as other males that approached. Females were more difficult to find. Over the four years of data presented here, we collected only 31 females (Table 1). I do not think that this reflects a skewed sex ratio as I have reared the progeny of both wild-caught and lab-reared females and the sex ratio of their offspring has never been significantly different from 50:50 (S. Murphy, unpublished data). Rather, the difference in the number of males and females caught probably represents a difference in their behaviors; indeed female rarity is common at hilltop sites in other hilltopping butterflies (Shields 1967). My observations of how rare females are on the hilltops is consistent with the notion that females only stay on top of the domes long enough to mate and then they fly downhill towards larval host plant sites. Once my field assistants and I had caught all of the males that were present on a dome upon our arrival, new males were observed flying up from lower elevations and they began to occupy the newly unoccupied perches. Given the difficulty in accessing some of the field sites, we were not able to sample every site every day. Hence, any females that arrived on days that we were not present were able to mate and fly away without our having ever encountered them. However, any males that arrived at a site on a day that we were not present were likely caught the next time we visited that site given their propensity to remain on the hilltops. For these reasons, I feel that my data are a rather accurate representation of the number of males that were present at these dome sites, but that the number of females has been significantly underestimated simply because their behavior makes them more difficult to catch when we could not be present at every dome site everyday.

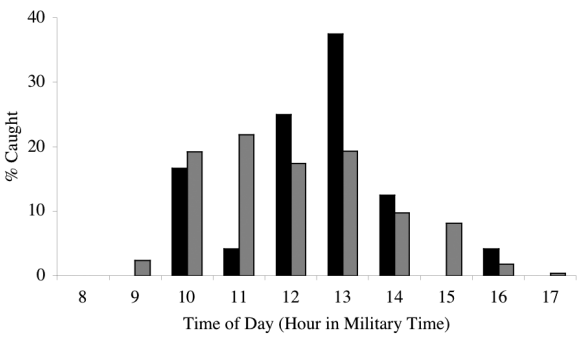

FIG. 1. Female (black bars) and male (gray bars) *Papilio machaon aliaska* butterflies that were caught during each hour of the day given as a percentage of the total caught. The data is given for all four field sites combined, but only for butterflies caught during the 2001–2003 field seasons (Females n=24; Males n=444).

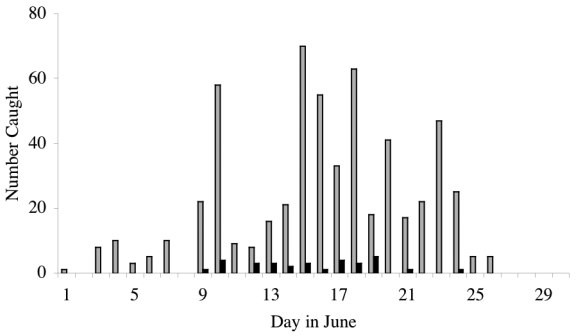

FIG. 2. Number of female (black bars) and male (gray bars) *Papilio machaon aliaska* butterflies that were caught during the month of June for all years (2000–2003).

I was able to find both males and females at each of the four sites described in the methods section above (Table 1). Males tend to be caught earlier in the day than females (Fig. 1), although none was ever caught before 9:00 hr. Their peak flight time was between 11:00-12:00 hr while the majority of females was caught slightly later, between 13:00–14:00 hr, but these two distributions for flight time did not differ significantly ($P > 0.1$, Wilcoxon signed-rank test on ranks). Females were never caught before 10:00 hr. Females also were caught a few days later than the first males were caught (Fig. 2). The earliest females were caught on June 9 while the latest females were caught on June 24. The earliest male was caught on June 1 while the latest male was caught on June 26.

Nearly 17% of the males (n=96) were recaught at the same field site during a subsequent visit (Fig. 3); males were never found to have traveled between sites, which is not surprising given the significant distances between them. The majority of these males were only recaught once, but a few were caught several times. One male was recaught six times in the same location on a dome, which I interpret to mean that he was occupying the same perch or territory for several days. Most males were recaught within four days of their initial catch date. A few, however, were caught many days later. This gives us some insight as to how long males can live in the field. For instance, at least one male lived a minimum of 18 days in the field.

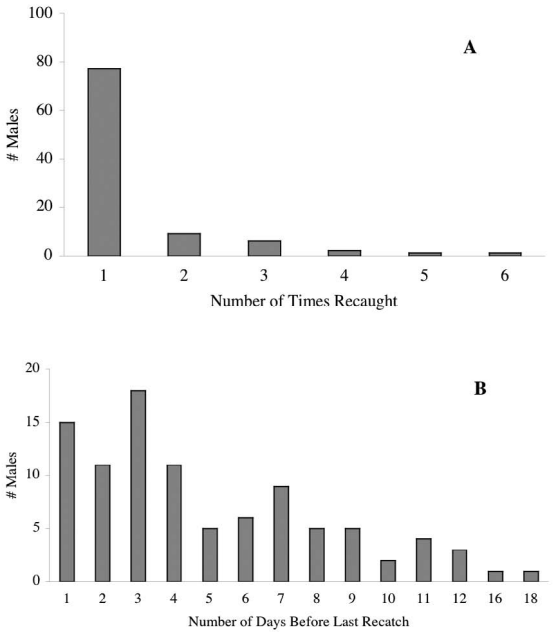

FIG. 3. Many male *Papilio machaon aliaska* butterflies (n=96) were caught, marked and released and then re-caught during this study (2000–2003). Of these males that were re-caught, many were caught multiple times. A) The number of times that the marked males were re-caught. B) The number of days that passed between the first time a male butterfly was caught and the last time he was caught.

Although not directly tested, my observations are consistent with the idea that males tend to establish territories at the top of the dome that they then occupy, as evidenced by the number of males that were recaught on the domes along with personal observations of their behavior before they were caught. Males tend to emerge earlier in the season than do females and also fly earlier in the day than females. Finally, while males are commonly found on the hilltops, females are rarer. Together, these data support the claim that *P. m. aliaska* is a hilltopping swallowtail butterfly.

ACKNOWLEDGEMENTS

I thank L. Hough, S. Rothman, P. Bennett and J. Goodman for assistance in the field and P. Feeny as well as three anonymous reviewers for helpful comments that greatly improved this manuscript. This work was supported by the Andrew W. Mellon Foundation, American Museum of Natural History Theodore Roosevelt Memorial Fund, Edna Bailey Sussman Fund, Explorer's Club Exploration Fund, Sigma Xi, Cornell University Department of Ecology and Evolutionary Biology, a NSF Doctoral Dissertation Improvement Grant awarded to S.M.M. (DEB-0104560) and a NSF research grant awarded to P. Feeny (IBN-9986250).

LITERATURE CITED

ALCOCK, J. 1985. Hilltopping in the nymphalid butterfly *Chlosyne californica* (Lepidoptera). American Midland Naturalist 113: 69–75.

BAUGHMAN, J. F., & D. D. MURPHY. 1988. What constitutes a hill to a hilltopping butterfly? American Midland Naturalist 120: 441–443.

CARTER, M., & P. FEENY. 1985. Techniques for maintaining a culture of the black swallowtail butterfly, *Papilio polyxenes asterius* Stoll (Papilionidae). Journal of the Lepidopterists' Society 39 :125–133.

FEENY, P., L. ROSENBERRY, & M. CARTER. 1983. Chemical aspects of oviposition behavior in butterflies. Pp. 27–76, *In* S. Ahmad (ed.), Herbivorous insects: host-seeking behavior and mechanisms. Academic Press, New York.

LEDERHOUSE, R. C. 1982. Territorial defense and lek behavior of the black swallowtail butterfly *Papilio polyxenes*. Behavioral Ecology and Sociobiology 10: 109–118.

MURPHY, S. M. 2004. Enemy-free space maintains swallowtail butterfly host shift. Proceedings of the National Academy of Sciences 101: 18048–18052.

——. 2007a. The effect of host plant on larval survivorship of the Alaskan swallowtail butterfly (*Papilio machaon aliaska*). Entomologia Experimentalis et Applicata 122: 109–115.

——. 2007b. Inconsistent use of host plants by the Alaskan swallowtail butterfly: Adult preference experiments suggest labile oviposition strategy. Ecological Entomology 32 :143–152.

—— & P. Feeny. 2006. Chemical facilitation of a naturally occurring host shift by *Papilio machaon* butterflies (Papilionidae). Ecological Monographs 76: 399–414.

PE'ER, G., D. SALTZ, H. H. THULKE, & U. MOTRO. 2004. Response to topography in a hilltopping butterfly and implications for modelling nonrandom dispersal. Animal Behavior 68: 825–839.

RUTOWSKI, R. L. 1991. The evolution of male mate-locating behavior in butterflies. American Naturalist 138: 1121–1139.

SCOTT, J. A. 1968. Hilltopping as a mating mechanism to aid the survival of low density species. Journal of Research on the Lepidoptera 7: 191–204.

——. 1974. Mate-locating behavior of butterflies. American Midland Naturalist 91: 103–117.

——. 1986. The butterflies of North America: a natural history and field guide. Stanford University Press, Palo Alto, CA.

SHIELDS, O. 1967. Hilltopping—an ecological study of summit congregation behavior of butterflies on a southern California hill. Journal of Research on the Lepidoptera 6: 69–178.

SPERLING, F. A. H. 1987. Evolution of the *Papilio machaon* species group in western Canada (Lepidoptera: Papilionidae). Quaestiones Entomologicae 23: 198–315.

THOMPSON, J. N. 1988. Variation in preference and specificity in monophagous and oligophagous swallowtail butterflies. Evolution 42: 118–128.

—— 1995. The origins of host shifts in swallowtail butterflies versus other insects. Pp. 195–203. *In* J. M. Scriber, Y. Tsubaki, & R. C. Lederhouse (eds.), Swallowtail butterflies: their ecology and evolutionary biology. Scientific Publishers, Gainesville, FL.

WIKLUND, C. 1981. Generalist vs. specialist oviposition behaviour in *Papilio machaon* (Lepidoptera) and functional aspects on the hierarchy of oviposition preferences. Oikos 36: 163–170.

Received for publication 29 May 2007; revised and accepted 25 March 2008.