2009 ACUB Project Progress Report

1. **Project Title:** Development of captive rearing and translocation methods for Taylor's checkerspot in south Puget Sound

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3. **Project Site (if appropriate):** Captive rearing - Oregon Zoo; Release and monitoring sites – Scatter Creek South Unit – 2007, 2008, 2009 releases; Scatter Creek North Unit, Pacemaker Airstrip – 2009 releases.

4. **Executive Summary**

Rapid extinction of several Taylor's checkerspot populations in south Puget Sound in the late 1990s illustrated the need for a proactive approach to recovery. Habitat restoration is proceeding on several sites. The goal of this project is to establish new populations to stem decline and move toward recovery. Funding was awarded for implementation of the Taylor's checkerspot captive rearing program in 2008-2009 and release and monitoring of Taylor's checkerspot at field sites in 2009. A captive rearing program for Taylor's checkerspot was established at the Oregon Zoo in 2004 and has been ongoing since that time. Large annual advances in captive propagation have resulted in high survival during all life stages from egg to adult; postdiapause rearing conditions are being refined to improve survival and weight gain during that phase; a two-year test of indoor vs. outdoor conditions was initiated in 2009. Cumulative survival from hatching to postdiapause was 91.9 percent (2522 survived of 2743 hatched larvae) in 2008-2009. This represents a significant increase in the scale of propagation efforts relative to 2007-2008, with negligible change in survival. Co-locating females with groups of males proved relatively successful as a captive mating strategy with 112 mating attempts resulting in 37 copulations; some males mated more than once. Captive propagation at the Oregon Zoo is at capacity with sufficient space and staff for about 2,000 postdiapause larvae; a second rearing facility will be established in 2010 to expand capacity and minimize risks of the captive propagation program.

A record number (2,247) of postdiapause larvae were released in 2009, with about 750 larvae released at each of three sites (Scatter Creek South, Scatter Creek North and Pacemaker Airstrip). Flight season monitoring at these sites in 2009 revealed few adults. Very cool weather until mid-May appeared to delay the flight season and is assumed to have influenced the outcome of the release, as numbers were also quite low at the source site on Fort Lewis. A total of 48 observations of adult Taylor's checkerspots were made during distance sampling surveys (n = 7) at Scatter Creek South, with a maximum of 19 adults observed in a single survey. Just two adult checkerspots were observed at Scatter Creek North and a single adult was observed at Pacemaker Airstrip. Releases of small numbers of postdiapause larvae at Scatter Creek South in 2007 and 2008 may have contributed to the higher numbers observed there relative to the other release sites, or may indicate more suitable habitat, although this is less likely at least in the case of Pacemaker. Similar to Scatter Creek South, adults at Scatter Creek North and Pacemaker were attracted to conifer trees 40 and 100 m, respectively, from release plots; some adults may have dispersed due to low densities, a phenomenon characteristic of male checkerspots. Because checkerspot larvae are capable of multi-year diapause, we do not know whether poor flight

season returns were the result of high post-release mortality, a high rate of return to diapause, or both. All release sites will be monitored again in 2010; no new releases will occur at Scatter Creek North and Pacemaker to improve our understanding of factors that may have influenced the poor returns in 2009. A fledgling population appears to be taking hold at Scatter Creek South and releases will continue there in an effort to bolster numbers and reduce risk of extinction. Adult behaviors observed at Scatter Creek South include nectaring, territorial displays by males, mating chases, routine movement patterns, and one oviposition observation. Collectively these behaviors suggest habitat recognition and confer a measure of site fidelity; the only known egg cluster disappeared prior to hatching. Habitat restoration continues in the vicinity of the release at Scatter Creek South and is expanding to accommodate additional release areas; work is also progressing at several other sites in South Puget Sound.

5. Project Goals and Objectives

The goal of this project is to reduce the probability of extinction of *Euphydryas editha taylori* in south Puget Sound by developing methods for captive rearing and translocation that can be used to re-establish wild populations. Specific objectives for 2008-2009 are listed below.

Captive rearing

1) Develop and refine methods for rearing Taylor's checkerspot through postdiapause, pupal and adult stages.
2) Increase the scale of Taylor's checkerspot production at the Oregon Zoo.
3) Evaluate the capacity for rearing Taylor's checkerspot at the Oregon Zoo and housing needs related to a captive breeding program.
4) Test hand-mating techniques.
5) Evaluate the efficacy of adding a second captive rearing facility at a different location (e.g., Woodland Park Zoo).

Release and monitoring

1) Quantify rates of adult emergence from release of postdiapause larvae,
2) Quantify the behavioral response of adult to nectar enhanced vs. control plots,
3) Describe and quantify the behavioral response of adult checkerspots to trees, and
4) Quantify the total number of adults at each site.

6. Methods

Captive rearing

In May 2008, nine female Taylor's checkerspots were captured at Fort Lewis immediately after copulating. They were brought to the Oregon Zoo in Portland for oviposition in order to: 1) quantify egg-laying potential for wild females, 2) compare those results with those of captive-reared and -mated females, and 3) eliminate the risk of introducing parasites into the lab from eggs or larvae collected in the wild.

Oviposition: Gravid wild and captive-reared females were placed singly in oviposition chambers comprised of 1-gallon potted *Plantago lanceolata* plants (larval host) fitted either with a plastic container covered with fabric netting and secured with a rubber band OR covered with netting supported by bamboo sticks and secured with a rubber band. Oviposition chambers were set on wire racks in front of a southeast-facing window. Supplemental light and heat was provided with 150-watt mercury vapor lamps from 10:00 AM-2:00 PM. Females were fed once daily with a honey solution while her host plant was checked for egg clusters. Eggs were harvested by cutting

off the Plantago leaf containing the egg cluster. Eggs were counted, the leaf trimmed to remove excess tissue, and then placed in a paper towel-lined yogurt cup. Oviposition chambers were placed outdoors in a sun tent for several hours on clear days.

Prediapause larvae: The rearing protocol followed that described in (Linders 2007) from the egg stage through removal from diapause. All larvae were reared on freshly cut *Plantago* leaves provided twice daily until the larvae stopped eating and entered diapause.

Diapause: A few days after larvae showed signs of entering diapause (cessation of eating and movement, webbing into clusters, molting into 5th instar), a subset of larvae from each rearing container was weighed individually to compare larval weights between offspring of captive-reared and wild females. After entering diapause, larvae were transferred to freshly-lined containers. On 25 August 2008, these were placed upright inside inverted clay pots located under the overhang of a building where they are sheltered from rain but exposed to some sun, air movements, and ambient temperatures. Clay saucers were wetted weekly with ½ cup of filtered tap water; larvae were checked every other week for condition, mortality and indications of movement. Larvae re-entering diapause were kept on the mezzanine in yogurt cups housed in bins lined with saturated blue paper towels. Eighty-five larvae survived until they were moved outdoors on 25 August 2008. Larvae were removed from diapause containers on two dates. Those destined for captive rearing trials were removed 25 February 2009. Those destined for release and those in 2nd year diapause were removed on 2 March 2009.

Postdiapause larvae: Postdiapause larvae were split into two groups according to destination. The largest group (2,252 larvae) was intended for release into the wild by the WDFW. A second group of 270 larvae (one cluster of 30 larvae from each of the 9 wild females) was retained for a captive rearing trial to look at the effect of indoor vs. outdoor rearing conditions on pupal and adult size and to provide adults for captive-mating. Variables of interest in the rearing trial include: pupal and adult weights; adult size (i.e., wing and abdominal measurements); and relative rates of survival, return to diapause, pupation and eclosion.

Clusters of larvae destined for release were combined for efficiency and housed in clear plastic Sterilite shoebox bins (12" long x 7.5" wide x 4.5" deep) lined with blue paper shop towels. Bins were covered with netting (tulle) and secured with a rubber band and a solid plastic lid. Lids were removed for a few hours daily for light and fresh air; 15-20 individuals were housed in each bin. Larvae were fed freshly cut and washed leaves of *Plantago lanceolata*. Food was placed on one end and a mounded paper towel was placed on the other end for basking. A moisture gradient was maintained across the bin.

Larvae used in the captive rearing trial were randomly assigned to indoor and outdoor treatments; offspring were divided equally by female. All postdiapause larvae were housed in Sterilite bins and treated in the same manner. Portable thermo-hygrometer (UEi brand, model DTH880, www.UEitest.com) was placed in a separate bin in each treatment and placed in the midst of the larval bins. Rearing conditions differed as follows.

The indoor group was housed in the lab, which was maintained at 65 ºF or lower with a relative humidity of about 55%. Bins were placed on wire racks with full spectrum fluorescent bulbs on a

12-hour light/12-hour dark cycle maintained by timers. Overhead lights were turned on during the day to increase light intensity. The lab also has a large (72" X 34") southeast-facing window that provides natural sunlight; it was left open in the evening and fitted with a fan to pull in cool air. Larvae were also provided with one or two 75-watt tungsten lamps for 4 hours/day to provide extra light and heat. Starting 11 March 2009 the lights were on for 3 hours per day, and the length was decreased to 2 hours per day on 18 March 2009. Temperature and moisture readings were taken between 11:00 AM and 1:00 PM from 28 February 2009 until 14 April 2009 for the indoor rearing trial. Average minimum temperature inside the bins was 56°F (range 50-68°F) and average maximum temperature was 72°F (range 66-82°F); average minimum relative humidity was 41 percent (range 31-57 percent) and average maximum was 64 percent (range 43-94 percent). Second diapause larvae were reared in the same manner.

Larvae reared outdoors were placed in a 12'w x 12' l x 9.5' h screen house with a waterproof vinyl roof. It was attached to a wooden floor made of plywood overlaid on pallets and covered with composite roofing paper. The inside of the tent was lined with a second layer of fine mesh. It was located on a treed slope with shade but open to full sun on the south side. Larvae were exposed to ambient temperatures with no additional light or heat provided. Bins containing larvae were aligned on a table parallel to the south side of the tent. Because ambient humidity was so high, bins were covered with mesh only and only a small amount of water was added to create a gradient. Temperature and moisture readings were taken between 11:00 AM and 1:00 PM from 28 February 2009 until 17 May 2009. The average minimum temperature was 39°F (range 26-52°F) and average maximum temperature 70°F (range 48-98°F); average minimum relative humidity was 46 percent (range 20-75 percent) and average maximum was 90 percent (range 51-99 percent).

Pupae: Bins were checked daily for pupae. Pupae were weighed using an electronic gram scale accurate to 3 significant figures, assigned an identification number and placed individually in paper towel-lined yogurt cups, which were housed in lined and netted bins. Moisture was maintained by misting the bins through the mesh twice each day.

Adults: Pupae were checked several times each day for signs of eclosion. Adults were sexed and those strong enough to eat and move around were assigned a number, weighed and photographed. Males received a unique mark on the left hind wing. Measurements will be obtained from photos of the hind wing and abdomen. Adults were grouped into three breeding "lineages" based on founding female. Emerging females were fed with a honey water solution, and placed in a yogurt cup in the refrigerator until mating. Males were housed in "bug dorm" tents (23.6"w x 23.6"l x 23.6"h) with other males from the same breeding group and allowed to "age", as they are thought to learn from one another (G. Pratt, pers. comm.).

Captive mating

A "hands-off" technique was used to induce butterflies to mate. This involved placing a group of males in a mini tent ("Insect Lore" Port a Bug, 10 x 10 x 10 in.) stationed in a sunny window, adding a chilled female and watching for breeding behavior. All mating attempts were documented. Data recorded included female identification number, male identification number, weather conditions, and length of copulation. When copulation was complete the male was

returned to his breeding group and the female fed and placed in an oviposition chamber. If no copulation occurred the female was fed and returned to the refrigerator for future mating trials.

Release and monitoring of postdiapause larvae in 2009
Prior to the release of larvae, baseline nectar resources and ground cover were assessed at two plots on each of three release sites (Scatter Creek North, Scatter Creek South, and Pacemaker Airstrip). Nectar resources were enhanced by a standardized amount at one plot in fall 2008, while the second plot at each site served as a control. Actual nectar abundance was assessed just prior to and immediately following the 2009 flight season.

On 6 March 2009 2,247 captive-reared postdiapause Taylor's checkerspot larvae were released at three locations in South Puget Sound. About 750 larvae were split between two 15 x 30-m release plots at each site; plots were buffered by 15 m on all sides to account for wandering larvae and to minimize impacts from management actions on the surrounding site. The weather at the time of release was warm and seasonal. We conducted post-release surveys on 12, 13, 18 March 2009 using belt transects to provide an indication of detectability rates.

Counts of adults associated with control and nectar-enhanced plots were conducted at both plot (transect) and site (distance sampling) scales to assess similarities and differences between sites. Behavioral monitoring of adults was also conducted with an emphasis on quantifying nectar, courtship, mating, and oviposition behaviors. Two of the three sites contained isolated trees, and behavior of adults in the vicinity of trees was characterized and quantified. Once adult butterflies were detected, flight season surveys were conducted as frequently as possible during the 2009 flight season, whenever weather conditions approached suitability (e.g., >10°C, wind <10 mph, bright sunlight to soft shadows).

Release of prediapause Taylor's checkerspot larvae
A total of 5,443 prediapause larvae were released on 12, 18 June 2009 into a single 30 x 30 m-plot on each of two sites [Fort Lewis AIA (2956) and Scatter Creek (2487)]. Since two early season fires in 2003, only a single butterfly has been observed on the Fort Lewis site in any given year. Scatter Creek is an approved ACUB site being restored for this species. Larvae were placed in groups of 10-20 on the host plant, *Plantago lanceolata*. Larvae are the offspring of captive- mated Taylor's checkerspots reared at the Oregon Zoo. This unplanned release resulted from increased effort and unexpected success in captive mating Taylor's checkerspots at the Oregon Zoo. Few adults were observed at the Fort Lewis source site in 2009, so no wild adults were collected. Instead the Zoo increased the number of adults included in captive mating trials. Simultaneously, a long run of cool cloudy weather was abruptly replaced by clear skies and temperatures in the 70s °F, which resulted in a dramatic increase in mating, oviposition and hatching success. Within one week the number of eggs laid increased from about 1,000 to over 10,000, and the hatch rate increased from 50 percent to nearly 100 percent. One post-release check of prediapause larvae at Scatter Creek was made on 22 June 2009 by walking the perimeter of the release plot. Fourteen large larvae were observed in addition to extensive foraging sign throughout the plot. Release plots will be monitored during the 2010 flight season.

7. Results and Discussion

Captive rearing

Oviposition: Eggs were obtained from 9 wild females and 11 females reared and bred in captivity in spring 2008. Wild and captive females appeared to differ in their oviposition patterns, although statistical testing is not yet complete. The average number of days from copulation until oviposition for captive-reared females was 3.5 days and for wild females it was 1.9 days. On average, wild females oviposited over a period of 13.5 days; captive females averaged 8.1 days. Wild females averaged 9.6 clusters per female with 29.2 eggs per cluster for an average of 229.3 eggs per female; a total of 2,515 eggs were laid by wild females. Captive females averaged 6.6 clusters with 15.2 eggs per cluster for an average of 100.8 eggs per female; a total of 1,109 eggs were laid by captive-reared females. Stage-specific survival is presented in Table 1 for animals reared at the Oregon Zoo in 2008-2009.

Prediapause larvae: We counted 2,743 second instar larvae, the earliest point at which an accurate larval count can be made. Of 2,515 eggs laid by wild females, 82.1 percent (2,064 larvae) reached 2nd instar and 94.6 percent (1,952 larvae) survived to enter diapause. Most egg clusters lost only a few larvae, but in one cluster all the larvae died inexplicably within a short period of time. Of 1,109 eggs laid by captive-reared females, 679 larvae (61.2 percent) reached 2nd instar, 665 (97.9 percent) of which survived to enter diapause.

Two larvae from 2008 continued to eat and grow after their cohort entered diapause. They eventually pupated and eclosed into one male and one female that promptly mated before they could be separated. The female laid 59 eggs of which 58 hatched (98.3 percent); 39 larvae (67.2 percent) survived to enter diapause in mid-September.

Table 1. Number, stage-specific survival and cumulative percent of total annual cohort for Taylor's checkerspots reared at the Oregon Zoo in Portland in 2008-2009. Released animals are removed from successive calculations of stage-specific survival.

Survival to next life stage	#	% stage survival	cumulative % of total
# eggs	3,624		
Egg to hatching	2,743	75.7	24.3
Hatching to warm diapause	2,590	94.4	28.5
Diapause study	*22*		
Warm diapause to cold	2,567	100.0	28.6
Cold diapause to postdiapause	2,522	98.2	30.4
Postdiapause release	*2,252*	*89.3*	37.9
Postdiapause to pupation	170	63.0	95.3
Pupal release	*na*	*Na*	na
Pupae eclosed as adults	165	97.1	95.4
# that re-entered diapause	90	33.3	97.5
Percent cohort eclosed Y1@ Zoo			4.6

Diapause: Larvae began to enter diapause 1 July 2008, with all 2,590 larvae achieving diapause by 17 July 2008. Diapause survival was very high (Table 1). Thirteen of 115 larvae (11.3 percent) from the second diapause group (2007-2008 cohort) emerged from diapause; 5 larvae in third year diapause (2006-2007 cohort) died. The average weight of postdiapause larvae from

captive-reared females was 0.047g (SD ± 0.003) and the average weight of larvae from wild females was 0.032g (SD ± 0.004); statistical testing is not complete.

Return to diapause: Larvae in the indoor rearing trial showed signs of returning to diapause beginning about 22 March 2009. Larvae in the outdoor trial did not show signs of returning to diapause until one month later. A total of 90 larvae went into second diapause and are being kept at the Zoo for use in the 2010 mating trials.

Pupae: Rearing trials appeared to differ between indoor and outdoor treatments with respect to development time, growth rate and activity level. The outdoor trial larvae were about one month behind the indoor trial larvae. Indoor larvae ate immediately and continued to eat at a consistent rate. On 9 March 2009, 10 days after the start of trial conditions, the first postdiapause molt was observed in the indoor group. The outdoor trial group did not molt until 40 days after the start of trial conditions. The first indoor pupa was seen on 23 March 2009, 24 days after starting the trial. The last pupa from the indoor trial was found 12 April 2009, before any larvae had pupated in the outdoors. The first outdoor pupa was found 1 May 2009, 63 days after the start of the trial.

There were measurable differences between rearing treatments in pupation rate and rate of return to diapause. Twice as many larvae went into second diapause from the outdoor group (60 of 135; 44.4 percent) as the indoor group (30 of 135; 22.2 percent). Conversely, the indoor group had more larvae pupate than the outdoor group (97 of 135 or 71.9 percent indoor; 73 of 135 or 54.1 percent outdoor). For about half of the clusters (n = 5), the number of larvae pupating versus going into 2nd diapause was similar (within 2 individuals) regardless of which rearing treatment they were in. This suggests both environmental and genetic factors may influence return to diapause. There was little difference in weight between pupae reared outdoors versus indoors, the main objective of the trial. This is planned as a two year trial.

Eclosion: Of 270 postdiapause larvae in the indoor-outdoor rearing trial, 165 or 61.1 percent eclosed as adults (93 indoor, 72 outdoor), including12 that eclosed improperly (11 indoor, 1 outdoor). Seventy-seven females (46 indoor, 31 outdoor) and 88 males (47 indoor and 41 outdoor) eclosed. Wing and abdominal measurements are being compiled and analyzed.

Captive mating

A total of 112 mating trials were conducted in 2009, 37 of which resulted in copulation; some males mated more than once. Because indoor adults emerged so much earlier than those outdoors, mating trials were somewhat sequential. Indoor males mated only with indoor females before expiring. Because females were refrigerated, however, they had the opportunity to mate with outdoor males. In addition, 6 second diapause adults were included in mating trials. Of the adults that copulated, 17 were from the indoor group (five males and 12 females) compared to 42 from the outdoor group (19 males and 23 females); two females and two males from the second diapause group copulated. The larger number of adults copulating from the outdoor group may have been due to the increase in sunny weather during their flight period. Sunlight proved crucial to success in both mating and oviposition. No mating attempts were successful unless there was enough sun to create shadows, even when artificial lighting and heat was provided. Similarly, females did not begin to oviposit until oviposition chambers were placed outside in direct sun; days with overcast skies resulted in little oviposition behavior.

Comparison of captive-reared versus wild adults in 2008
We compared wild adult checkerspots with their captive-reared counterparts from the rearing trials using weight as well as wing and abdomen size. The average weight of 18 males captured from Fort Lewis (0.0780g; SD $\pm$ 0.0132) was significantly less than the average weight of 25 captive-reared males (0.0870g; SD $\pm$ 0.0143)(ANOVA, F 4.479, df 1, p <0.05). The average weight for 13 wild females (0.1580g; SD $\pm$ 0.0217) was significantly greater than the average weight of 29 females reared at the Zoo (0.1236g; SD $\pm$ 0.0198)(ANOVA, F 25.034, df 1, p <0.01). Higher weight in females is typically correlated with higher egg production; this pattern was observed at the Oregon Zoo in 2008 (see Oviposition results). Data on the relative weights and sizes of captive adults as well as four adults emerging at Scatter Creek South was collected in 2009, but is still being analyzed.

Post-release monitoring 2009
Results of 2009 flight season monitoring are still being compiled. Flight season monitoring at three postdiapause release sites in 2009 revealed few adults. Very cool weather until mid-May delayed the flight season and is assumed to have influenced the outcome of the release, as numbers were quite low at the source site on Fort Lewis. A total of 48 observations of adult Taylor's checkerspots were made during distance sampling surveys (n = 7) at Scatter Creek South, with a maximum of 19 adults observed in a single survey. Just two adult checkerspots were observed at Scatter Creek North and a single adult was observed at Pacemaker Airstrip. Few complete distance surveys were completed at these sites due to lack of adult activity; most searching was done during the course of behavioral surveys. Releases of small numbers of post diapause larvae at Scatter Creek South in 2007 and 2008 may have contributed to the higher numbers observed there relative to the other release sites. Adults at Scatter Creek North and Pacemaker were associated with conifer trees 40 and 100 m, respectively, from release plots; some adults may have dispersed due to low densities, a phenomenon characteristic of male checkerspots. Because checkerspot larvae are capable of multi-year diapause, we do not know whether poor flight season returns resulted from high post-release mortality, a high rate of return to diapause, or both. Release sites will be monitored again in 2010; no new releases will occur at Scatter Creek North and Pacemaker to improve our understanding of factors that may have influenced the poor returns in 2009. A fledgling population appears to forming at Scatter Creek South; releases will continue in an effort to bolster numbers and reduce extinction risk.

Adult behaviors observed at Scatter Creek South include nectaring, territorial displays by males, mating chases, routine movement patterns, and one oviposition observation. Collectively these behaviors suggest habitat recognition and confer a measure of site fidelity. At all sites butterflies were attracted to lone conifer trees, gathering at those closest to the release plots and moving routinely between adjacent trees. Searches of host plants at the oviposition site during the prediapause larval phase did not reveal any offspring. However small population size, poor weather, and apparent female bias observed in spring 2009 would have reduced the likelihood of detecting rare, sparsely distributed larval clusters. The release of postdiapause larvae in 2009 was somewhat disappointing in terms of the number of adults; however they may be less surprising in light of what appeared to be very low numbers of adults at the source site on Fort Lewis as well. The release of late postdiapause larvae has been an encouraging approach overall and has produced healthy adult butterflies in three consecutive years (2007-2009). However,

successful Taylor's checkerspot reintroduction may rely on maintaining a flexible approach, both because of the plastic nature of the species in general and also because highly variable weather conditions may cause high variability in the success of any one release.

All release sites will be monitored again in 2010; no new releases will occur at Scatter Creek North and Pacemaker in an effort to understand the role of weather as a factor that may have influenced the poor returns in 2009. A fledgling population appears to be taking hold at Scatter Creek South and releases will continue there in an effort to bolster numbers and reduce risk of extinction. Habitat restoration continues in the vicinity of the release at Scatter Creek South and is expanding to accommodate additional release areas; work is also progressing at several other sites in South Puget Sound.

8. Future Plans

This is the fourth year of a multi-year project. Additional work remains in compiling and analyzing data from 2008-2009, for both the captive and field components of this project. A 2009 biennial report will be compiled and distributed. It will include the final details and analysis of the 2007-2009 captive rearing and captive mating effort as well as results-to-date from translocation efforts. Funding appears to be sufficient to complete the existing reporting. Funds for the 2010-2011 field season and rearing year are being requested from USFWS as well as ACUB; the goal is to expand the size of releases and maximize the number of release sites to offset the influence of climatic perturbations on translocation success. Additional sources of funding and new conservation partnerships are also being explored.

9. Further Information Available

Andersen, M., D. Shepherdson, S. Rosen, E. Barclay. 2007. Oregon Zoo Taylor's checkerspot (*Euphydryas editha taylori*) rearing 2006-2007. Final report. Oregon Zoo, Portland, Oregon.

Linders, M. J. 2006. Captive rearing and translocation methods development for Taylor's checkerspot (*Euphydryas editha taylori*), South Puget Sound, Washington. Washington Department of Fish and Wildlife, Olympia.

Linders, M. J. 2007. Development of captive rearing and translocation methods for Taylor's checkerspot (*Euphydryas editha taylori*) in South Puget Sound, Washington: 2006-2007 Annual Report. Washington Department of Fish and Wildlife, Wildlife Program, Olympia.

10. Questions for Further Research

1) What role does the timing and severity of summer drought play in prediapause larval survival of Taylor's checkerspot and how would we expect global warming to affect this relationship?
2) What is the average and range of survival rates for prediapause Taylor's checkerspot larvae in an established population in South Puget Sound? What are the primary sources of mortality?
3) What are the mechanisms that lead to site fidelity? How do sites with only a few adults in any given year persist over time?