Western Riverside County
Multiple Species Habitat Conservation Plan
Biological Monitoring Program

2020 Delhi Sands Flower-loving Fly
(*Rhaphiomidas terminatus abdominalis*)

28 April 2021

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NOTE TO READER:

This report is an account of survey activities conducted by the Biological Monitoring Program for the Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP). The MSHCP was permitted in June 2004. Reserve assembly is ongoing and is expected to take 20 or more years to complete. The Conservation Area includes lands acquired under the terms of the MSHCP and other lands that have conservation value in the Plan Area (called public or quasi-public lands in the MSHCP). In this report, the term "Conservation Area" refers to these lands as they were understood by the Monitoring Program at the time the surveys were conducted.

The Monitoring Program monitors the status and distribution of the 146 species covered by the MSHCP within the Conservation Area to provide information to Permittees, land managers, the public, and the Wildlife Agencies [i.e., the California Department of Fish and Wildlife (CDFW, formerly California Department of Fish and Game) and the U.S. Fish and Wildlife Service]. Monitoring Program activities are guided by defined conservation objectives for each Covered Species, other information needs identified in MSHCP Section 5.3 or elsewhere in the document, and the information needs of the Permittees. A list of the lands where data collection activities were conducted in 2020 is included in Section 7.0 of the Western Riverside County Regional Conservation Authority (RCA) Annual Report to the Wildlife Agencies.

The primary author of this report was the 2020 Delhi Sands flower-loving fly Survey Lead, Tara Graham. This report should be cited as: Biological Monitoring Program. 2020. Western Riverside County MSHCP Biological Monitoring Program 2020 Delhi Sands flower-loving fly Survey Report. Prepared for the Western Riverside County Multiple Species Habitat Conservation Plan. Riverside, CA. Available online: https://www.wrc-rca.org/species-surveys/.

While we have made every effort to accurately represent our data and results, it should be recognized that data management and analysis are ongoing activities. Any reader wishing to make further use of the information or data provided in this report should contact the Monitoring Program to ensure that they have access to the best available or most current data.

Please contact the Monitoring Program Administrator with questions about the information provided in this report. Questions about the MSHCP should be directed to the Executive Director of the RCA. Further information on the MSHCP and the RCA can be found at www.wrc-rca.org.

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INTRODUCTION

The Delhi Sands flower-loving fly (*Rhaphiomidas terminatus abdominalis*; Delhi fly) is federally listed as endangered and is narrowly distributed in portions of Riverside and San Bernardino Counties in areas with Delhi series soils. The species is known to have occurred within three Core Areas defined by the Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP): Jurupa Hills, Agua Mansa Industrial Center, and Mira Loma (Dudek & Associates 2003). To date, conservation of the species within the MSHCP Plan Area has only occurred at the Teledyne site within the Jurupa Hills Core Area (Figure 1). There are no lands that are currently part of the Conservation Area within the other two Core Areas for this species; however, the Rivers and Lands Conservancy has been actively procuring lands in San Bernardino County in those general areas for Delhi fly conservation.

The Delhi fly has distinctive biological and habitat requirements and faces a number of threats. The life cycle of the Delhi fly includes egg, larval, pupal, and adult stages. Only the adult stage occurs above-ground when adults emerge to breed during the summer months. The species is restricted to fine, sandy Delhi series soils, usually with wholly or partly stabilized sand dunes and sparse native vegetation. Areas with suitable Delhi fly habitat have been highly affected by anthropogenic activities, including conversion to agriculture, residential and commercial development, surface mining for sand, dumping of trash and cow manure, and damage by off-road vehicles. Invasive exotic plants are also thought to degrade Delhi fly habitat by increasing vegetation cover or by altering soil conditions through dune stabilization and changes in soil moisture (USFWS 1997).

The Delhi fly Conservation Objective 1 states that successful reproduction shall be documented at all Core Areas once a year for the first 5 years after permit issuance and then as appropriate, but not less frequently than every eight years thereafter (Dudek & Associates 2003). Reproductive success is defined in the MSHCP as the presence of pupal cases (exuviae) or newly emerged (teneral) individuals. Because Delhi fly is an endangered species with an extremely limited distribution within the Plan Area, Monitoring Program biologists have surveyed for Delhi fly within the lone accessible Core Area annually since 2005. We describe here the procedure and results of the MSHCP Biological Monitoring Program's 2020 effort to monitor Delhi fly in the Jurupa Hills.

Survey Goals and Objectives

1. Document successful reproduction by Delhi fly at the Teledyne site in the Jurupa Hills Core Area.
    a. Record observations of teneral individuals and/or exuviae.
2. Estimate population density of adult Delhi fly during flight season at Teledyne.
    a. Document occurrences of Delhi fly individuals.
    b. Calculate distance sampling-based estimates of population density that account for animal detectability.
3. Document persistence of the population within appropriate habitat and potential expansion of occupied area as a result of vegetation management.

   a. Record observations of adult individuals to potentially assess trends in distribution in response to management activities or other conditions.
4. Gather data regarding Delhi fly resource selection and important distribution covariates including co-occurring insect Families within Core Areas.
   a. Record all co-occurring insect Families while conducting Delhi fly surveys.
   b. Conduct ground-dwelling arthropod surveys every 5 years.
5. Determine vegetation and soil characteristics occurring across the Teledyne site and compare site characteristics between sampling years.
   a. Conduct vegetation surveys every 5 years.
   b. Record soil moisture and temperature characteristics in the dunes area using the weather station.
6. Monitor the spread of short-pod mustard (*Hirschfeldia incana*) and non-native grasses (Poaceae) across the dune system at the Teledyne site.
   a. Record digital images annually from three photo-stations to document changes in vegetation structure and composition.
7. Monitor the weather conditions that affect the Delhi fly behavior at Teledyne
   a. Record relative humidity, rainfall, air temperature, soil temperature, soil moisture using the weather station.

METHODS

Protocol Development

We began surveying for Delhi fly in 2005 following the *Interim General Survey Guidelines for the Delhi Sands Flower-loving Fly* (USFWS 1996). These U.S. Fish and Wildlife Service (USFWS) guidelines were developed to determine presence/absence of Delhi fly by slowly traversing appropriate habitat. We modified the USFWS protocol in 2005 by establishing line-transects and measuring the perpendicular distance between the transect centerline and individual Delhi fly observations, with the goal of estimating population density and detection probability following distance sampling methodology (Buckland et al. 2001). This method was used for surveys conducted from 2005-2010, and 2014 to present. Due to personnel and resource limitations, surveys conducted 2011-2013 were reduced to a general site search to simply document successful reproduction. The survey protocol used in 2020 is described more completely in the *Western Riverside County MSHCP Biological Monitoring Program Protocol for Delhi Sands Flower-loving Fly Surveys* and is available from the Biological Monitoring Program. The weather conditions are ongoing as the weather station records data all year.

Training

All surveyors studied a Delhi fly-specific training manual prepared by the Biological Monitoring Program, relevant invertebrate field guides, and preserved specimens of co-occurring winged invertebrate species. We placed emphasis on the ability to recognize morphological and behavioral field traits of Delhi fly, and proficiency in identifying all co-occurring winged insects to family. We also trained surveyors to differentiate between adult and teneral individuals in a field setting, and to identify plant species common at the

Teledyne site. All surveyors participated in field-based training that involved observing, capturing either with a net or by hand, and identifying co-occurring insects to family. Prior to conducting line-transect surveys independently, surveyors passed the USFWS Delhi fly practical exam.

Study Site Selection and Transect Placement

The Teledyne site is located in the Jurupa Hills along the Riverside-San Bernardino County border in the vicinity of Pyrite Street (Figure 1). The site encompasses 6.08 ha of Delhi series soils and is primarily composed of coastal sage scrub vegetation (Dudek & Associates 2003). Common plants found at the site include *Eriogonum fasciculatum*, *Ambrosia acanthicarpa*, *Amsinckia menziesii, Croton californicus, Rhus aromatica, Brassica* spp., and various non-native grasses.

We established 32 permanent transects at the Teledyne site in 2005 by first delineating Delhi series soils within the target area as identified by the USFWS (1997). The transects were parallel and spaced 15-m across the delineated area, randomly oriented along a 28° bearing. Transects were 44 – 222 m in length for an aggregate length of 4.94 km. However, if a transect traversed dense vegetation that made it logistically impossible to walk the transect without significant damage to vegetation, we eliminated those portions of the transect from the survey. The eliminated portions added up to 162 meters in 2020, therefore the total aggregate length of surveyed transects was 4.78 km. We placed fiberglass stakes or a flag on shrubs on the centerline of each transect to ensure there was a visible mark every 30 – 40 m to ensure easy navigation and accurate distance measurements from the transect centerline to observed Delhi fly. We regularly replaced missing markers.

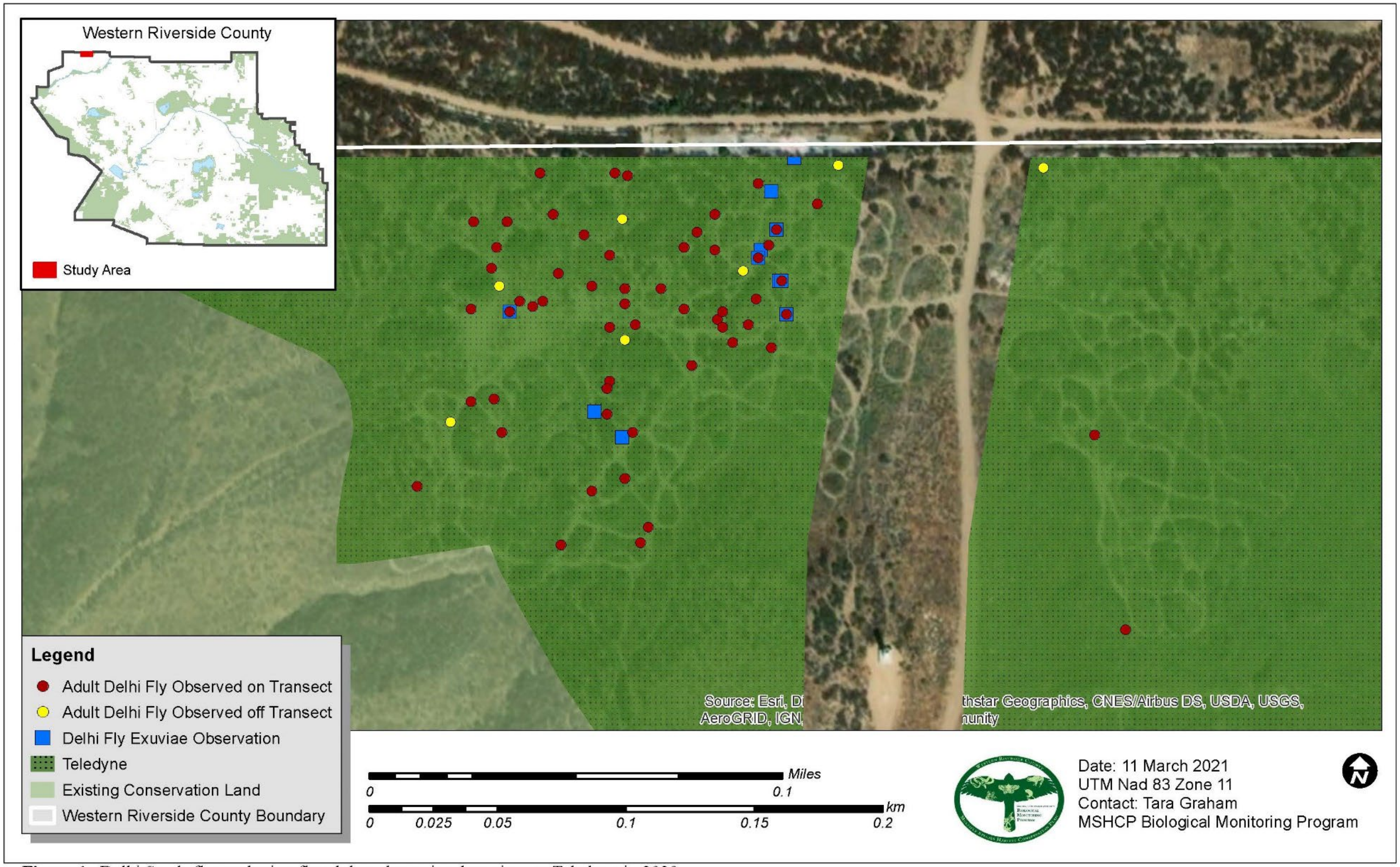

Figure 1. Delhi Sands flower-loving fly adult and exuviae detections at Teledyne in 2020.

Survey Methods

We divided the survey area into three sections (aggregate transect length range: 1,524 – 1,839 m) and surveyed each section once or twice a day depending on available personnel. When two observers were available, each observer surveyed whole sections and started from opposite ends of the survey site, usually resulting in at least one section being surveyed twice per survey day. When only one individual was available, the observer surveyed as many whole sections as possible once. We recorded time, general weather description, temperature (°C) in shade 1 m above ground, and average wind speed (mph) at the start and end of each survey. We walked each transect at approximately 0.987 km/h. When we observed a Delhi fly, we immediately marked the initial location of the individual with large metal washers with attached flagging or a pin flag. We ensured accurate distance-to-detection measurements by clearly marking transect centerlines and carefully recording the perpendicular distance between the transect centerline and Delhi fly markers. Observers then recorded transect ID, UTM coordinates, time, sex, activity, substrate if the Delhi fly was perched, age class (1-3) of the detected Delhi fly and photo numbers if photos were taken. Any flies detected during an active survey were recorded on the datasheets; Delhi fly observed outside of an active survey (e.g., before the start time or after the end time of a survey) were recorded as incidental observations. Non-target winged insects were identified to family but distance to detection was not measured. If possible, we took photos of teneral Delhi fly individuals. Surveyors took care to avoid disturbing any individuals that were detected. Exuviae are expected to degrade relatively quickly if not discovered, so their presence in a given survey year is assumed to represent emergence of new individuals in the year of discovery. When Delhi fly exuviae were detected, the surveyors recorded the UTMs of the location, then placed their GPS unit next to the exuviae (to make the exuviae location more apparent in a photograph) and stepped back 4-5 meters to take a photo of the exuviae and the surrounding habitat. The surveyors then collected the exuviae to avoid double counting it in future surveys. The exuviae are stored at the Biological Monitoring Program office to be used in future training.

To gather data regarding Delhi fly resource selection, in addition to continuing to record co-occurring insect families during active Delhi fly surveys, we plan to conduct ground-dwelling arthropod surveys every 5 years. A baseline survey was conducted in 2016 and we are planning to conduct them again in 2021.

To determine vegetation and soil characteristics occurring across the Teledyne site we conduct vegetation surveys every 5 years. This survey was last conducted in 2016 and we are planning to conduct them again in 2021.

To monitor the spread of invasive mustard (*Hirschfeldia incana*) and non-native grasses (Poaceae) across the dune system, we established three permanent photo stations in 2006. We chose to monitor these species because they may pose a threat to Delhi fly through dune stabilization (USFWS 1997) and are included in vegetation management activities by the Management Program at this site. We revisited photo stations again in 2020 and took digital images in the four cardinal directions to document vegetative cover and species composition. These images are stored with those from previous years and will be used at a later date to track vegetation changes through time and to visually complement quantitative changes in vegetation when additional vegetation surveys are conducted in the future.

To monitor the weather conditions that affect the Delhi fly behavior at Teledyne, on June 1, 2017, we installed a HOBO Data Loggers (model U30) weather station in the upper dunes area where most Delhi flies are observed. Data on relative humidity (%), rainfall (inches), air temperature (°C), soil temperature (°C) at a depth of 6 inches, soil moisture (m^3/m^3) at a depth of 1 meter was manually downloaded once a month during the flight season and every 2-3 months outside the flight season depending on the availability of personal. On 20 December 2018 we installed a second soil moisture sensor at a depth of 2 meters to getter better information about the moisture layer the larvae live in (Ken Osborne, consultant, personal communication).

RESULTS

Data Analysis

We began 2020 line-transect surveys on 25 June after the first Delhi fly was detected at Teledyne during a scouting survey on 23 June, therefore, not included in the density analysis, and ended the surveys on 8 September after no Delhi fly were observed for four consecutive survey days. We observed adult Delhi fly on-transect on 65 occasions and off-transect on 8 occasions (Figure 1) note that the blank strip through the middle of the figure is a Metropolitan Water District parcel not currently included in the MSHCP Conservation Area), with observations ranging from 25 June to 28 August (Figure 2); Of those observations, 52 were male, 15 were female and 6 of undetermined sex. Of the 73 individuals observed while conducting surveys, 9 were teneral.

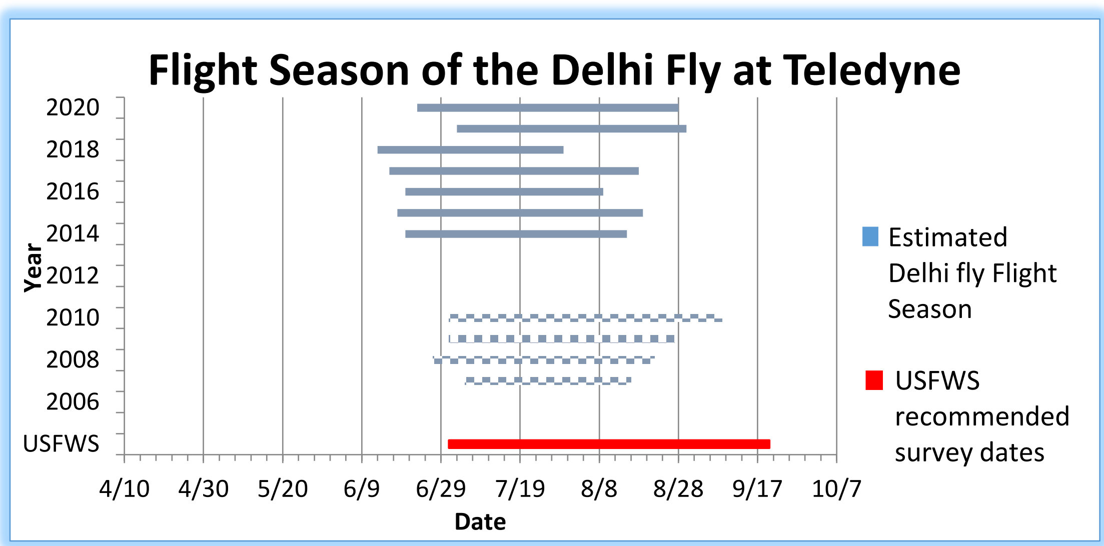

Figure 2. The observed Delhi Sands flower-loving fly flight season from 2007-2020. The dates shown in red are the USFWS recommended survey dates for the Delhi fly. The checkered lines represent years we did not attempt to observe the first adult Delhi fly before beginning surveys.

Only Delhi fly observations that occurred on-transect resulted in distance measurements and were used for density estimate calculations. In total, we conducted surveys on 31 days between 08:20 h and 15:59 h. We walked a total of 92 km over the course of the 31 survey days which resulted in 0.79 Delhi fly observations per km surveyed (Figure 3).

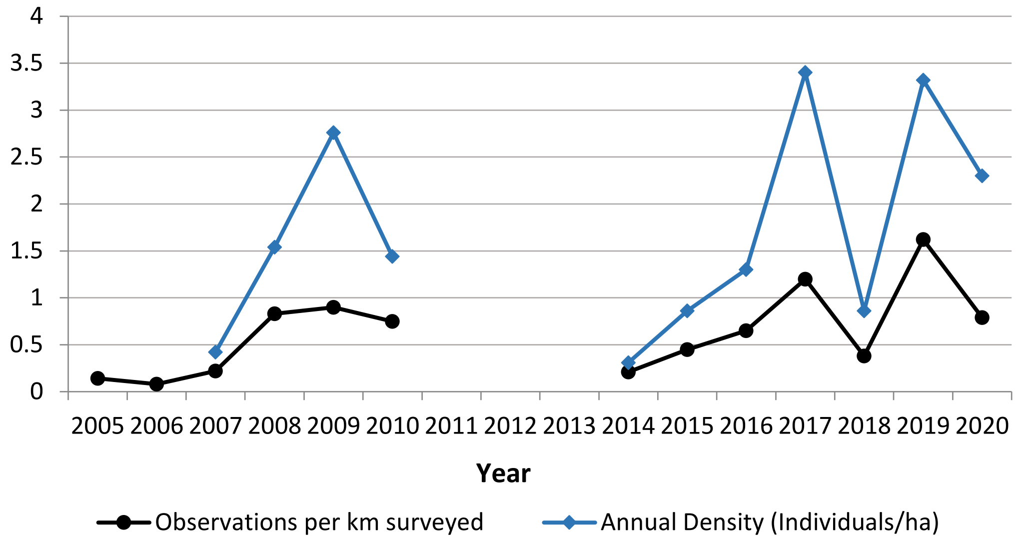

Figure 3. Delhi Sands flower-loving fly observations (per km surveyed) and annual density estimates (individuals per ha) from 2005-2020. Surveys from 2011-2013 were conducted following a different protocol, therefore those data are excluded. From 2005-2006 there were insufficient data to obtain densities, therefore those years are excluded.

We used distance-sampling methodology and Program DISTANCE to estimate detection probability and population density of Delhi fly at the Teledyne site in 2020 (Buckland et al. 2001; Thomas et al. 2009). Distance sampling allows for density estimation with incomplete detection of animals (i.e., not all animals present need to be observed to estimate density). The method relies on fitting data to a pre-defined detection function based on the assumption that objects become less detectable with increasing distance from the observer (Buckland et al. 2001). Distance sampling also requires that three assumptions be met: 1) complete detection of subjects on the transect line, 2) subjects are detected at their initial locations, and 3) distances are measured accurately (Buckland et al. 2015). We examined detection histograms (i.e., number of observations per distance category) across the survey period for spikes in the number of observations away from the transect (which could indicate the observer was not recording the initial location of the observation suggesting violation of assumption 2), and for relatively few observations near the transect centerline in relation to other distance categories (which could indicate the observer did not detect every Delhi fly on the transect or they did not record the initial location of the observation suggesting violations of assumptions 1 and 2; Figure 4).

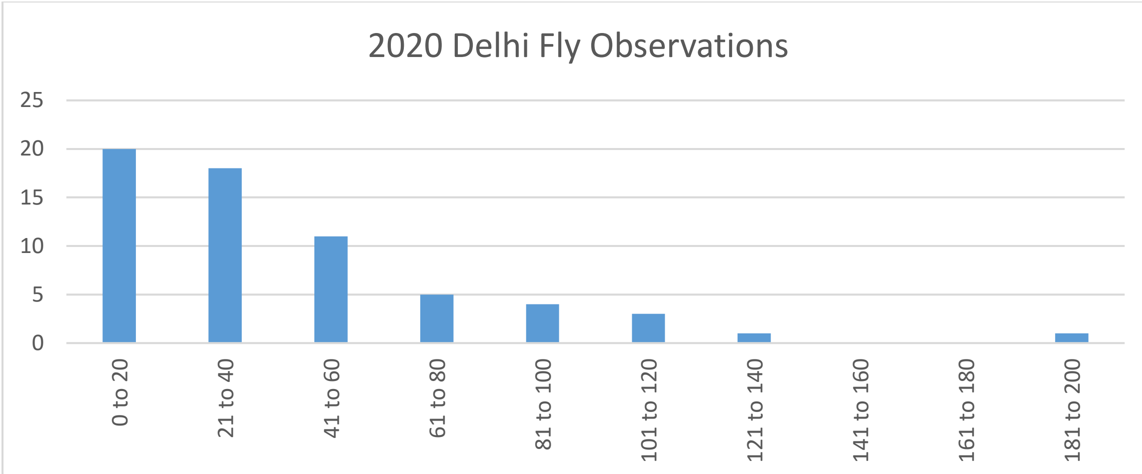

Figure 4. Observations of the Delhi fly showing distance from the transect, grouped in 20-inch increments.

We pooled data across the entire 2020 survey season to fit a detection function, and derived both stratified (i.e., daily) and pooled (i.e., average daily) estimates of population density. From our dataset, we removed any observations that had been measured beyond 200 inches from the transect to avoid fitting detection functions with extended 'tails.' Lastly, based on recommendations generated by the DISTANCE software pertaining to our dataset, we grouped observations into ten equal intervals (i.e., 0, 20, 40, 60…200 inches; Buckland et al. 2001). We evaluated the full combinations of uniform and half normal key functions with cosine, simple-polynomial, and Hermite-polynomial series expansions (Buckland et al. 2001). We did not use the hazard-rate key function because this model function frequently overestimates the unknown parameters, specifically the rate of death of the subject of study, unless the detection function curve is tightly matched to the hypothetical curve (Buckland et al. 2001). We assessed model fit by graphical inspection of the detection function and using a chi-square goodness of fit test. We excluded models from the candidate set that demonstrated significant lack of fit based on the above criteria. We ranked competing models using Akaike's Information Criterion adjusted for small sample size (AICc).

The density estimate of Delhi fly at Teledyne in 2020 was 2.3 individuals/ha (95% CI: 1.6-3.1); (Figure 3) and the detection probability was 0.51 (95% CI: 0.42-0.63). The top three performing models (half-normal key function with a cosine polynomial expansion, half-normal key function with a simple polynomial expansion and half-normal key function with a hermite polynomial expansion, data used in all models were divided into ten equal intervals and truncated at the largest 5%) resulted in a chi-square goodness of fit score of 0.97 and an AICc value of 200.57 for all of them, indicating that none of these models were superior to each other in describing the 2020 data (Table 1). The fourth top ranked distance model (uniform key function with a cosine polynomial expansion) was within 0.71 delta AICc of the 3 top performing models, meaning that the half-normal models were more somewhat superior to the uniform model in describing the 2020 data. We visually checked the detection function curve shape criterion and confirmed an appropriate detection function curve for each model. Estimated Delhi fly density peaked on the tenth survey day (17 July) at an estimated 13.10 individuals/ha, and then oscillated between five and zero individuals/ha until 31 August when it reached zero individual/ha.

Table 1. All models analyzed with their respective AICc and GOF Chi-p values.

Model	AICc	GOF Chi-p
5% Truncation 10 Equal Intervals Half-normal Cosine	200.57	0.973
5% Truncation 10 Equal Intervals Half-normal Hermite	200.57	0.973
5% Truncation 10 Equal Intervals Half-normal Simple	200.57	0.973
5% Truncation 10 Equal Intervals Uniform Cosine	200.74	0.945
5% Truncation 10 Equal Intervals Uniform Simple	202.92	0.804
5% Truncation 10 Equal Intervals Uniform Hermite	204.23	0.494
10 Equal Intervals Half-normal Cosine	227.19	0.955
10 Equal Intervals Half-normal Hermite	227.19	0.955
10 Equal Intervals Half-normal Simple	227.19	0.955
10 Equal Intervals Uniform Cosine	225.23	0.815
Equal Intervals Uniform Simple	228.84	0.393
Equal Intervals Uniform Hermite	231.23	0.149
5% Truncation Half-normal Cosine	575.67	0.402
5% Truncation Half-normal Hermite	575.67	0.402
5% Truncation Half-normal Simple	575.67	0.402
5% Truncation Uniform Cosine	574.66	0.473
5% Truncation Uniform Simple	576.31	0.393
5% TruncationUniform Hermite	578.56	0.284
10 Equal Intervals Truncation Beyond 200 Half-normal Cosine	227.19	0.955
10 Equal Intervals Truncation Beyond 200 Half-normal Simple	227.19	0.955
10 Equal Intervals Truncation Beyond 200 Half-normal Hermite	227.19	0.955
10 Equal Intervals Truncation Beyond 200 Uniform Cosine	225.23	0.815
10 Equal Intervals Truncation Beyond 200 Uniform Simple	228.84	0.393
10 Equal Intervals Truncation Beyond 200 Uniform Hermite	231.23	0.149
No Intervals Truncation at largest dist Half-normal Cosine	615.51	0.327
No Intervals Truncation at largest dist Half-normal Simple	615.51	0.327
No Intervals Truncation at largest dist Half-normal Hermite	615.51	0.327
No Intervals Truncation at largest dist Uniform Cosine	613.5	0.224
No Intervals Truncation at largest dist Uniform Simple	615.88	0.079
No Intervals Truncation at largest dist Uniform Hermite	646.26	0

A total of 11 exuviae were collected in 2020, all of which were collected during active surveys (Figure 1). Nine exuviae were found northeast of the upper dunes, one in the dunes and two southeast of the dunes. This distribution is similar to the exuviae distribution we observed on-site in 2018 and 2019.

The Delhi fly larvae most likely lives in the moisture layer that is in the general area of 2 meters below the surface and moves up or down based on environmental conditions, based on the life cycle of other closely related Rhaphiomidas species. Once they leave the moisture layer the larvae will not survive long (Ken Osborne, consultant, personal communication). In order to learn what triggers Delhi fly emergence we have looked at the values from the sensors on the HOBO weather station in the 2 days prior to the first Delhi fly observation. In these 2 days the daily average of the soil temperature (°C) was been between 28.66 and 32.24, the daily average of the soil moisture (m^3/m^3) at a depth of 1 meter was between 0.462 and 0.474 and the daily average of the soil moisture (m^3/m^3) at 2 meters was between 0.451 and 0.466. (The data for the 2-meter soil moisture sensor only includes data from 2019 and 2020 since it wasn't installed until December 2018). In 2020, the average daily soil temperature (°C) was between 28.66 and 30.24, which is on the low end of the 3-year average. The soil moisture (m^3/m^3) at a depth of 1 meter was 0.474 both days which is on the higher end of the 3-year average and the soil moisture (m^3/m^3) at a depth of 2 meters was between 0.462 and 0.466 which is on the higher end of the 2-year average (Figure 5).

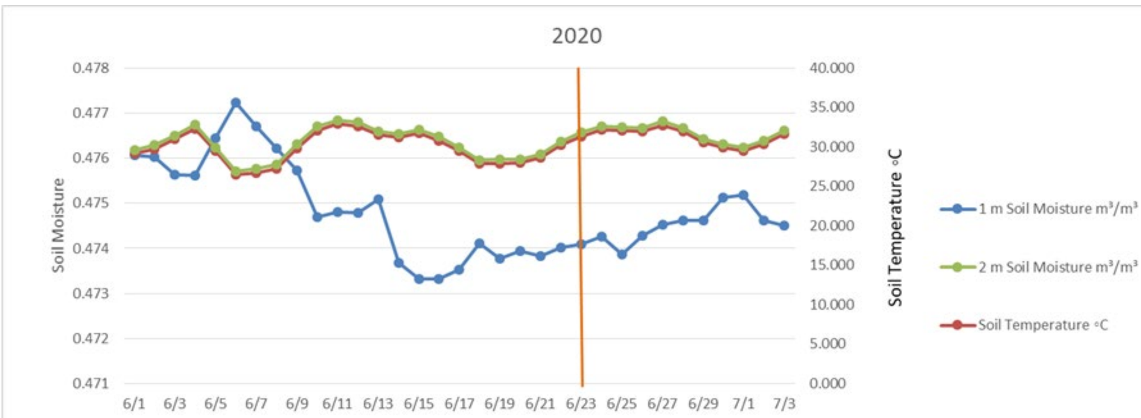

Figure 5. Weather station data for 2020 showing the conditions before the first observation of the Delhi fly.

DISCUSSION

In 2020, our goals were to document successful reproduction by Delhi fly at Teledyne, estimate population density of adult Delhi fly to compare to previous estimates, document persistence of the population within appropriate habitat, gather data regarding Delhi fly resource selection and important distribution covariates and record soil characteristics. We met the monitoring objective at Teledyne by confirming successful Delhi fly reproduction again in 2020, documenting nine teneral individuals and 11 exuviae during active surveys. The first Delhi fly individual was observed on 23 June and the final individual of the flight season was observed at the Teledyne site on 28 August. These observations remain noteworthy as the USFWS Recovery Plan states that the flight season historically did not begin until early August (USFWS 1997) which was later revised to begin 1 July (USFWS 2004). After the late start of the flight season in 2019 of 3 July, our data in 2020 no longer suggests a distinct temporal shift in the flight season for this species at the Teledyne site, however, our data shows, in every year we have been conducting surveys, the end of the flight season is close to a month before USFWS had originally suggested (Figure 2). In 2020 the first observed individual was seen on 23 June which was nearly 2 weeks earlier than in 2019. In an effort to accurately detect the start of the flight season, we will continue to start scouting surveys in early June. Continued tracking of these environmental parameters over time may help us to identify trends that influence Delhi fly emergence.

Density estimates and observations per km in 2020 decreased slightly from 2019. The daily density estimate in 2020 was 2.25 individuals/ha, which is comparable to the density in 2009 (2.8 individuals/ha; Figure 3). The number of Delhi fly observations per km surveyed was 0.79 in 2020, which is significantly lower than 1.65 observations per km surveyed in 2019. The total number of survey hours in 2020 was 92.7 comparable to 91.7 total survey hours in 2019. We will continue to keep this intensity of survey hours to maintain the sample size to get a more accurate density estimate while continuing to reduce potential impacts on teneral flies, which have been observed emerging from the sandy open spaces along the line transects. In 2020 the average speed of surveyors was 0.987 km per hour. Across the 12 years we have performed transect surveys, the average walking speed of surveyors has been between 0.7 to 1.4 km/hour. There appears to be no correlation between observer speed and annual density estimates. Since the time it takes for a surveyor to complete the survey depends on the number of observations and the behavior of the Delhi fly, we cannot standardize the time required to complete each survey. In years with a high number of observations the speed at which our surveyors complete the survey with be lower and years with low number of observations our surveyor speeds will be higher.

As noted in previous years, we detected most Delhi fly individuals in the western section of the site where soils are generally sandier and looser and vegetation is sparse (Figure 1). Furthermore, surveyors generally detected Delhi flies on the edges of vegetation, rather than in the middle of the open sand dune or in the middle of thicker patches of shrubs or trees. This observed behavior could be due to the added protection the vegetation provides. Habitat management activities by the MSHCP Management Program initiated at Teledyne since 2015 (RCA), which includes weeding and maintaining paths through the vegetaion, seem to be preliminarily successful at improving site conditions for Delhi fly, as evidence by the Delhi fly's use of the pathways created by the management activities.

Based on the weather information collected during 2018 to 2020, there is a distinct pattern emerging with respect to the Delhi fly emergence and some environmental conditions. For all 3 years, in the couple of days prior to the first observation of the Delhi fly the soil temperature has been between 28.66 and 32.24 degrees, a very narrow range of 3.58 degrees. The soil moisture at 1 meter has been between 0.462 and 0.474 (m^3/m^3) which is a narrow range of 0.012 (m^3/m^3). This presents very specific conditions in the 2 days prior to the larvae emerging. The underground values for 2020 show as the soil temperature raises so does the soil moisture at the 2-meter depth, however, at the same time the soil moisture at the 1 meter depth lowers The soil moisture at 2 meters appears to be positively correlated with the soil temperature while the soil moisture at 1 meter shows an opposite patterns, however further analysis will have to be done to make any definitive conclusions (Figure 5).

Recommendations

Future Surveys

The species-specific monitoring objective for Delhi fly states that successful reproduction shall be documented at all Core Areas once a year for the first five years after permit issuance and then as appropriate, but not less frequently than every eight years thereafter. The MSHCP permit was issued in 2004; therefore, further surveys to document successful annual reproduction of Delhi fly are not strictly mandated. However, given the endangered status of the species and the minimal effort required to document successful reproduction at the sole occupied site within the Plan Area, we will continue to monitor the Delhi fly annually.

Furthermore, evaluating the efficacy of ongoing efforts by the Management Program to improve habitat conditions (RCA 2019) for Delhi fly at Teledyne requires the more intensive line-distance transect study design. Density estimates during and post-management can then be compared to earlier measures to track the population status of Delhi fly onsite. Modeling density and detection probability is important as it allows us to regularly estimate the density of individuals and determine whether changes in the number of detections are due to changes in Delhi fly abundance or changes in detectability. Line transect sampling allows us to model detection probability and density in order to better describe population changes at occupied sites, especially as active habitat management continues. In addition to the vegetation surveys conducted every 5 years, we recommend continuing to conduct ground-dwelling arthropod surveys, every 5 years, in order to track the relative abundance and richness of the arthropod community, which the predacious Delhi fly larvae presumably utilize as a food resource (Ken Osborne, consultant, personal communication and Rick Rogers, entomologist, personal communication). These data could additionally serve as a habitat quality indicator of the Delhi sand dunes at Teledyne (Hulton VanTassel et al. 2013). We plan to continue to conduct the line-transect study in 2021, as opposed to the area searches done in 2011 – 2013, to monitor potential effects of management activities and Delhi fly population fluctuations. Vegetation and soil characteristics should continue to be monitored in conjunction with ongoing management actions conducted as described by the Delhi Sands flower-loving fly Habitat Management Plan (Marchant 2005) and Delhi Sands flower-loving fly Habitat Management Update (RCA). We recommend continuing to monitor the weather conditions at the Teledyne site to further learn what about the needs of the Delhi fly.

We recommend and plan on conducting both the vegetation and arthropod surveys in 2021 as well as the annual monitoring of the mustard through photo documentation.

We also recommend performing late afternoon surveys to observe and collect data on the resources the female Delhi fly utilizes for oviposition (USFWS 1997).

ACKNOWLEDGEMENTS

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Department of Fish and Wildlife. Program staff who conducted Delhi fly surveys in 2020 were: Masanori Abe, Tara Graham, Esperanza Sandoval and Taylor Zagelbaum. Jonathan Reinig (MSHCP Management Program) also conducted Delhi fly surveys in 2020.

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