EFFECTS OF TEMPERATURE AND LIGHT CYCLE ON THE DEVELOPMENT OF *APHELINUS NIGRITUS* (HOWARD) IN THE SOUTHERN GREAT PLAINS

By

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Bachelor of Science in Biology

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Corvallis, OR

2019

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
December, 2022

EFFECTS OF TEMPERATURE AND LIGHT CYCLE

ON THE DEVELOPMENT OF *APHELINUS NIGRITUS*

(HOWARD)

IN THE SOUTHERN GREAT PLAINS

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Date of Degree: DECEMBER 2022

Title of Study: EFFECTS OF TEMPERATURE AND LIGHT CYCLE ON THE DEVELOPMENT OF *APHELINUS NIGRITUS* (HOWARD) IN THE SOUTHERN GREAT PLAINS

Major Field: ENTOMOLOGY AND PLANT PATHOLOGY

Abstract:

The Southern Plains of North America are a humid subtropical region. Drastic temperature changes are common, but multivoltine insects must adapt to allow their offspring to survive—understanding how climate and weather influence pests and their natural enemies in agricultural crops is essential. With the introduction of sorghum aphids (*Melanaphis sorghi)* into the area, the abundance of *Aphelinus nigritus* has increased. Studies suggest a correlation between sugar cane aphid populations and *A. nigritus* parasitism rates. However, very little is known about this species' developmental requirements or how they transition to and survive cold winter months.

This study consists of three experiments across two objectives. Objective i was to determine lower temperature thresholds and degree-day requirements for *A. nigritus* development, and objective ii was to characterize the effects of photoperiod and temperature on A. nigritus development. In objective i, microcosms were placed in one of four environmental chambers maintained at constant temperatures and one fixed light-dark cycle: 14, 18, 22, and 26ºC each at 16:8 L:D cycle. The number of days from oviposition to mummy, mummy to adult, and oviposition to adult were recorded. Each individual's developmental rate (1/days) was calculated for the three described developmental periods. Total development (Oviposition to Adult) ranged from 12.8-45.4 days. On average, the total degree day requirement of *A. nigritus* was 216.15 degree days with an average lower developmental threshold of 9.064ºC. In objective ii, microcosms were maintained at one of 6 temperature fluctuation x day length environmental conditions (14-10ºC and 28-24ºC daily fluctuations each at 15:9 L:D, 12:12 L:D, and 9:15 L:D) to assess how these conditions influenced growth and development of offspring. We assessed the effect of parental exposure to environmental change and immature exposure to environmental change. Results indicate that exposure to lower fluctuating temperatures and shorter days cause delays in development greater than those expected for *A. nigritus*. Delayed development associated with the onset of average winter conditions indicates that *A. nigritus* is entering oligopause.

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INTRODUCTION AND OBJECTIVES

The North American Great Plains represent a vast region of fertile land ranging from Southern Canada to Southern Texas and across most of the central United States. This region experiences a wide range of extreme weather conditions, from rainfall and wind patterns to dramatic temperature fluctuations and long-distance insect migrations (Michaud 2010), which significantly affect local crop production. Sorghum is arguably one of the most important crops in the Great Plains of the United States, and Texas and Oklahoma are among the top three grain-sorghum-producing states in the country (USDA 2019). Despite sometimes harsh and unpredictable summer droughts, sorghum's ability to produce constant yields makes it a profitable crop in this area (Elliott et al. 2021).

Sorghum has at least 150 different insects that feed on it (Guo et al. 2011), and aphid species are among the most economically important. Several aphid species target most parts of the plant during feeding, complete several generations within a single growing season, and have the potential to significantly injure plants and cause yield loss (Guo et al. 2011). Four major aphid species regularly infest sorghum worldwide: *Schizaphis graminum* (greenbug), *Rhopalosiphum maidis* (corn leaf aphid), *Melanaphis sorghi* (sorghum aphid), and *Sipha flava* (yellow sugarcane aphid) (Michels and Burd 2007, Brewer et al. 2022). Each of these aphids is commonly found throughout the Great Plains, but a recent invasive species, *M. sorghi*, has been significantly damaging (Giles et al. 2008, Michaud 2010, Elliott et al. 2021). Losses from *M. sorghi* in South Texas alone have exceeded $30 million, and when combined with losses in other areas of the Great Plains, this aphid has the potential to be an annual pest (Zapata et al. 2016, Elliott et al. 2021).

Since grain sorghum typically has a lower profit margin than other crops grown in the area, regular insecticide applications to control aphid populations are not economically sustainable (Elliott et al. 2021). Additionally, insecticide applications are not sustainable long-term as they may lead to the development of resistance (Elliott et al. 2021). Several alternative methods for aphid control already exist for grain sorghum, such as the use of tolerant hybrids and conservation of natural enemies that have been shown to maintain aphids below Economic Injury Levels (Faris, Elliott, et al. 2022). A combination of plant resistance and biological control can be interactive, resulting in a reduced probability that aphid pests will reach economic injury status and more sustainable sorghum production systems (Brewer and Elliott 2004, Brewer et al. 2022).

There are a variety of aphid natural enemies in sorghum throughout the Great Plains, including lady beetles, damsel bugs, lacewings, syrphids, and parasitoid wasps (Maxson et al. 2019). Pest control by these natural enemies has been well documented (Rice and Wilde 1988, Brewer and Elliott 2004, Michels and Burd 2007, Giles et al. 2008, Zapata et al. 2016, Jaimes-Orduna et al. 2020, Brewer et al. 2022). However, one parasitoid, *Aphelinus nigritus* (Howard), has emerged as an important mortality factor for

M. sorghi (Giles et al. 2021, Brewer et al. 2022, Faris, Brewer, et al. 2022). Little is known about the biology of this aphelinid parasitoid, its foraging strategies, functional and numerical responses, or even basic ecology, such as temperature-dependent development and seasonality (Elliott et al. 2019).

The overall goal of this thesis was to investigate how changing environmental conditions may influence the biology of *A. nigritus*. Information about basic biological functions is fundamental to detailed studies on seasonal population dynamics, plant resistance, pesticide efficacy, and conservation biological control (Damos and Savopoulou-Soultani 2011, Guo et al. 2011, Khaliq et al. 2014). Given that *A. nigritus* must survive highly variable and often harsh environments of the Great Plains, including extreme temperature changes, the objectives of this research were to:

i. Determine lower temperature thresholds and degree-day requirements for *A. nigritus* development.
ii. Characterize the effects of photoperiod and temperature on *A. nigritus* development.

Objective I will establish the biological relationship between temperature and development, allowing for generation time estimates under different environmental conditions. Results from objective ii will provide information on how changing temperatures may influence the seasonal biology of *A. nigritus* and whether this parasitoid enters dormancy in response to environmental changes typical of the region.

LITERATURE REVIEW

Wheat and sorghum in the southern Great Plains

Winter wheat and sorghum are often grown in rotation in the southern Great Plains of the United States (Tarkalson et al. 2006). In Oklahoma, roughly 73% of the land is used for farming and ranching, and historically, over 3 million acres of wheat are planted and harvested each year. Winter wheat is typically planted from September through November, and harvest generally occurs between May and July (Bolin et al. 2005, USDA 2019). The annual national value of winter wheat production varies from $2-10 billion, depending on market value, with winter wheat production in Oklahoma representing over half of the state's total revenue from crops (Sowell and Swearingen 2022). Winter wheat can be grown for grain only but may also be grazed or grown as a hay crop or cover crop for soil conservation or green manure. In addition, cattle may graze through fall and winter before being removed before the crop reaches the first hollow stem growth stage and then harvested for grain, thus serving a dual purpose (Bolin et al. 2005).

Sorghum is commonly grown in rotation with wheat and is usually planted in May through July following wheat harvest and harvested through November (Criswell et al. 2009). Sorghum is a C4 crop and thus one of the top five cereal crops with highly efficient solar energy conversion and water usage; it is a high-energy, drought-tolerant, resource-conserving crop, traits that make it an essential summer grain crop in the

Southern Great Plains ("Sorghum 101" 2022). The area of the United States with the highest sorghum production is known as the "sorghum belt," and it ranges from south Texas to South Dakota (Lindenmayer 2019, "Sorghum 101" 2022), which coincides with the Great Plains region. In 2021, the United States was the world's largest producer of grain sorghum at a production of 454 million bushels ("Sorghum 101" 2022). There are four categories of sorghum: grain, forage, sugar/sweet, and biomass, which are used for livestock feed, ethanol production, and human consumption, the most common being grain sorghum (Lindenmayer 2019). As reported in the 2017 Census of Agriculture, 26.9 billion kg of sorghum valued at $1.5 billion was produced in the United States, with Texas and Oklahoma ranking second and third among the 21-grain sorghum-producing states (Perdue and Hamer 2019). Sorghum is one of the few crops that can reliably produce acceptable yields despite harsh environmental conditions characteristic of the Southern Plains (Elliott et al. 2021).

Cereal aphids on the southern Great Plains

Aphids (Hemiptera: Aphididae) are significant pests of grains, especially when grown as expansive monocultures (Andow 1983, Ahern and Brewer 2002, Brewer and Elliott 2004, Men et al. 2004, Giles et al. 2008). Aphids are phloem-feeders and divert plant nutrients for their growth and reproduction. Additionally, they can act as vectors of plant viruses, and their honeydew can facilitate the growth of sooty molds that impede photosynthesis (Dedryver et al. 2010, Peairs 2016). Aphids are the most abundant insect pests on both sorghum and wheat in the Southern Plains, and greenbug (*Schizaphis graminum*) is perhaps the most critical cereal aphid shared by these crops (Brewer and Elliott 2004, Nuessly and Nagata 2005, Royer et al. 2015, Sowell and Swearingen 2022). Aphid outbreaks caused by the indirect effects of pesticide applications can severely impact winter and summer grains in this region (Kindler et al. 2002, Nuessly and Nagata 2005). Greenbugs produce enzymes that break down cell walls and chloroplasts in susceptible plants, causing characteristic chlorotic lesions. Unabated feeding can cause yellow and red leaf spots, leaf and root death, yield loss, and, eventually, plant death (Kindler et al. 2002, Nuessly and Nagata 2005).

Many other species of aphids are found on sorghum and winter wheat. Bird cherry-oat aphid (*Rhopalosiphum padi*), sorghum aphid (previously called sugarcane aphid, *Melanaphis sorghi*), and corn leaf aphid (*Rhopalosiphum maidis*) are the most common; however, their pest status varies among years and locations (Giles et al. 2021, Brewer et al. 2022). In 2013, the sorghum aphid became invasive in North America and appeared in 38 counties across four states. By 2015, sorghum aphids expanded their range to over 400 counties in 17 states in the United States and Mexico, causing millions of dollars in losses (Bowling et al. 2016, Elliott et al. 2021). Their ability to overwinter on annual and perennial hosts in southern latitudes, along with the annual wind-assisted movement of alates, facilitated the rapid spread of sorghum aphids northward (Bowling et al. 2016, Koralewski et al. 2020).

Aphid parasitoids in wheat and sorghum

It has been hypothesized that the overlap between winter wheat and sorghum growing seasons creates a 'green bridge' effect for insects that attack both crops (Giles et al. 2021). Indeed, winter wheat and sorghum share many of the same insect pests, predators, and parasitoids (Colares et al. 2015a, Bowling et al. 2016, Brewer et al. 2017, Salas-Araiza et al. 2017, Rodríguez-del-Bosque et al. 2018, Maxson et al. 2019, Elliott et al. 2021, Brewer et al. 2022). Predators of these pests include various species of coccinellids, chrysopids, hemerobiids, and syrphids (Elliott et al. 2021). In addition to predators, several species of solitary parasitoid wasps aid in aphid pest suppression. The most common parasitoids are *Lysiphlebus testaceipes* (Cresson) and *Aphelinus nigritus* (Howard) (Elliott et al. 2021, Brewer et al. 2022, Faris, Brewer, et al. 2022). Historically, *L. testaceipes* has been the most abundant parasitoid in these systems (Kring and Gilstrap 1983, Gilstrap et al. 1984, Elliott et al. 2019). However, following the invasion of the *M. sorghi*, *A. nigritus* has increased in abundance in both wheat and sorghum (Giles et al. 2021, Brewer et al. 2022).

Lysiphlebus testaceipes is a solitary aphidiine endoparasitoid, and its biology and ecology are well described (Starý et al. 1988, Royer et al. 2001, Shufran et al. 2004, Jones et al. 2008, 2014, Hughes et al. 2010, 2011, Hopkinson et al. 2013, Mullins et al. 2013, Elliott et al. 2018). Adults are about 3 mm long, and newly emerged females first seek mates and then search for aphid colonies. Females lay eggs inside the thorax of the aphid, and the resulting larva feeds on the living aphid, ultimately ending in its death, leaving nothing but the exoskeleton for the larva to utilize as protection during pupation. Parasitized aphids appear as swollen, tan-colored 'mummies' once the parasitoid larva begins pupation. Once fully developed, the adult parasitoid cuts a circular hole in the mummy and emerges (Knutson et al. 1993, Shelton 2022). *L. testaceipes* is the region's dominant parasitoid in winter wheat (Elliott et al. 2018, Giles et al. 2021), representing >90% of parasitized aphids, and the frequency of its mummies have been incorporated into aphid management guides (Giles et al. 2017). The importance of *L. testaceipes* in winter wheat has been attributed to its functional and numerical responses, but also its cold weather tolerance (Jones 2005, Jones et al. 2008).

Aphelinus nigritus is a solitary Aphelinidae endoparasitoid regularly found on sorghum during the summer (Gilstrap et al. 1984, Maxson et al. 2019) and at low levels on winter wheat during the fall and spring in the southern Great Plains (Kring and Gilstrap 1983, Elliott et al. 2019, Giles et al. 2021). They are smaller than *L. testaceipes*, ranging from 1-2 mm in length, but have been observed to contribute to significant mortality of cereal aphids throughout the Southern Great Plains (Archer et al. 1974, Gilstrap et al. 1984, Maxson et al. 2019, Elliott et al. 2021, Brewer et al. 2022, Faris, Brewer, et al. 2022). *Aphelinus nigritus* mummies are identified by their black color and flattened appearance. The last larval instar will pupate, and the adult will emerge after cutting a circular hole in the aphid exuviae. Adult females cause mortality by host feeding and parasitism (Maxson et al. 2019).

Little is known about the life history traits of *A. nigritus*, including its functional and numerical responses. Studies on their thermal requirements for development and their seasonal dynamics, including overwintering strategies, are incomplete. Langston (1967) conducted preliminary studies and observed a developmental period of 12 days for *A. nigritus* at warm temperatures (21-32ºC). While this information is a vital first step to understanding *A. nigritus* development, it is insufficient to predict seasonal development patterns in the Great Plains. Interestingly, in the Central-to-Northern Great Plains (Kansas, Eastern Colorado, and Southern Nebraska), *A. nigritus* is rarely found actively parasitizing aphids in winter wheat until late spring (Rice and Wilde 1988, Giles et al. 2008, Elliott et al. 2019, 2021), suggesting the possibility that this species overwinters in a dormant state, with delayed emergence.

Insects are exothermic, meaning their body temperature is determined primarily by ambient environmental temperature. However, species have adapted various mechanisms to maintain more stable physiological states, and they do this through thermoregulation and heat exchange (May 1979). Insects use a variety of mechanisms to maintain stable, physiological body temperatures, including altering the amount of melanin in their cuticle (Kutch et al. 2014), basking and perching (Piou et al. 2022), and orienting their body towards the sun (Anderson et al. 1994). Temperature is the primary factor influencing rates of metabolism and development (Jones and Brunner 1993), and insects have maximum and minimum thermal limits at which their growth and development can occur. For most species, there is a predictable linear relationship between development and temperature within a temperature range (Colinet et al. 2012), and temperature models can be used to predict critical events in insect life history by degree day accumulation (Bessin and Villanueva 2019). This information is vital for predicting seasonal population dynamics and has implications for pest management, aiding the prediction of pest and natural enemy activity in changing environments (Colinet et al. 2015).

An enormous body of literature summarizes degree-day models for insects, and several studies have documented temperature thresholds and thermal requirements for aphid parasitoid development. For example, degree day requirements for *Aphidius matricariae* were reported to be 273.1 ± 5.9 degree days above a threshold of 4.5 ± 0.4ºC, with no adult emergence at 31ºC (Miller and Gerth 1994). The number of degree days required for *Aphidius ervi* development to mummy stage was reported to be 146.3 degree days above a threshold of 6.8ºC, with development to adult requiring an additional 85.3 degree days above a threshold of 3.9ºC (Malina and Praslička 2008). Similarly, Basheer et al. (2014) reported 192.2 degree days above a threshold of 2.33ºC for *Diaeretiella rapae* development to mummy and an additional 90.1 degree days above a threshold of 3.36ºC for adult emergence. These wide ranges suggest that temperature requirements vary greatly and that individual species should be evaluated separately.

The dominant aphid parasitoid on the Great Plains, *L. testaceipes*, has a developmental threshold between 5.6-6.6ºC and takes 181-188 degree days to complete development (Royer et al. 2001). No information is available for *A. nigritus*, but developmental thresholds for other aphelinid species have been documented, e.g., *Aphelinus mali*, *Aphelinus varipes*, and *Aphelinus albipodus*, all introduced species on the Great Plains (Asante and Danthanarayana 1992, Lajeunesse and Johnson 1992, Lee and Elliott 1998, Yashima and Murai 2012). For example, Lee and Elliott (1998) reported a requirement of 205 degree days above a threshold of 9.7ºC for *A. albipodus.* Asante and Danthanarayana (1992) reported a developmental threshold of 8.3ºC for *Aphelinus mali* and 254.8 degree days for complete development. Lajeunesse and Johnson (1992) reported that *Aphelinus varipes* require 188.7 degree days above a developmental threshold of 11.3ºC. Interestingly, Yashima and Murai (2012) reported a requirement of 204.1 degree days for *Aphelinus varipes* above a threshold of 9.6ºC. These last two studies justify the need to examine differences in regional populations of the same parasitoid species because local selection pressures shape the evolutionary responses of local populations (Hopper et al. 2019).

The development of parasitoid degree day models can be integrated into aphid population dynamics models and Integrated Pest Management decisions (Giles et al. 2017). Combining this information with current integrated pest management practices is vital for more sustainable IPM programs that rely on biological control. Since A. nigritus is adapted to the Great Plains, we might expect developmental thresholds and degree day requirements similar to related species. When combined with field sampling, producers can use these predictions to calculate when *A. nigritus* will most likely become active in their region, thus guiding pest suppression tactics in sorghum and winter wheat. These predictions, accompanied by field sampling, should allow producers to optimize net returns.

Parasitoid dormancy

Understanding how seasonality affects biological functions is critical for describing local and regional population dynamics of important cereal aphid parasitoids. It can also enhance our understanding of dormancy strategies utilized by insects to survive adverse seasonal conditions. Dormancy is a state of inactivity or arrested development and "an evolved physiological adaptation to overcome adverse environmental conditions of a particular climatic zone" (Mansingh 1971). Insect dormancy falls into three categories: diapause, oligopause, or quiescence. These categories represent a sequence of evolutionary adaptations for development commonly dependent upon cyclic abiotic conditions in the organism's environment and characterized by varying degrees of arrested growth and development. The category a species falls into depends upon the nature and extent of deviation of the environmental factors from optimal conditions due to variations in weather (Mansingh 1971, Tatsumi and Takada 2006).

Diapause is the most extreme category of dormancy and is characterized by an extended period of arrested growth, cessation of feeding, complex biochemical changes, and is under complete endocrine control. It is often present in populations exposed to extreme adversity, such as long, cold winters or hot, dry summers. Quiescence is the least extreme category of dormancy and is often characterized as sudden, unanticipated, and non-cyclic. It is usually short-term and may occur at any life cycle stage. There are only slight setbacks in growth, feeding is essential, and there are often very simple biochemical adjustments. Between these two extremes is oligopause, characterized by some growth arrestment, slight and fast biochemical adjustments, and periodic dependence on food. It is generally seen in populations in areas of mild winters or summers (Mansingh 1971, Tatsumi and Takada 2006).

Strategies of dormancy may vary among populations (Pires et al. 2000, Han et al. 2005, Lu et al. 2013, Välimäki et al. 2013, Oliva et al. 2018). Whereas most cases of dormancy are induced by seasonal changes in temperature and photoperiod (Mansingh 1971), dormancy also can be induced by other factors (Mansingh 1971, Brodeur and McNeil 1989). For example, Brodeur and McNeil (1989) demonstrated that complex interactions among parasitoids, aphids, and environmental factors over multiple generations can influence diapause induction in some aphid parasitoids.

Diapause in aphid parasitoids is trigged primarily by environmental changes experienced by the developing larva (Flanders et al. 1961, Hamilton 1973, Gulmahamad and DeBach 1978, Gerard 1985, Trimble et al. 1990, Bernal and González 1996). More recently, Tatsumi and Takada (2006) reported evidence of adult oligopause and larval diapause in *Aphelinus asychis*, revealing evidence of arrested development of adults within mummies. No information on the dormancy of *A. nigritus* exists; however, field studies have suggested that spring activity in the northern Great Plains is delayed relative to expected degree-day accumulations for Aphelinidae generally (Giles et al. 2008, Elliott et al. 2019). Thus, more detailed investigations of aphid parasitoid overwintering and diapause on the Great Plains are needed.

CHAPTER I

Determining lower temperature thresholds and degree-day requirements for *A. nigritus* development

Introduction

Winter wheat and sorghum are two of the most essential and widely grown crops in the U.S. Southern Plains. Winter wheat is the most significant crop in the region and is typically planted from September-October and harvested from May-June depending on forage or grain yield goals (DeVuyst and Halvorson 2004, Zhang et al. 2017, Elliott et al. 2018). Sorghum is a billion-dollar industry in the United States, and production in Kansas, Oklahoma, and Texas typically represents approximately 80% of total hectares (Hawthorn 2018, Lindenmayer 2019, Kothari et al. 2020). Grain sorghum is predominately a full-season summer dryland grain crop, but also grown for forage and typically planted between April-July and harvested in late summer or early fall. Short-season varieties can be double-cropped following winter wheat harvest (Hmielowski 2018, Lindenmayer 2019). Late-planted sorghum and winter wheat production in this region of the U.S. overlap in agricultural landscapes during the late summer and early fall, and these crops share common pests and natural enemies.

Aphids are ubiquitous pests of winter wheat and sorghum and are found throughout the Southern Plains (Butts and Schaalje 1994, Boeve and Weiss 1998, Brewer et al. 2019, Elliott et al. 2021). Aphids can reproduce rapidly and have the potential to cause severe damage in a short amount of time; however, natural enemies are regularly observed maintaining populations below economic injury levels (Kring and Gilstrap 1983, Gilstrap et al. 1984, Zhang and Swinton 2009, Royer et al. 2020, Giles et al. 2021). In particular, aphid parasitoids provide critical pest suppression in sorghum and winter wheat throughout the Southern Plains (Elliott et al. 2021, Giles et al. 2021, Faris, Elliott, et al. 2022).

The two most commonly found Nearctic parasitoids in these crops are *Lysiphlebus testaceipes* (Cresson) and *Aphelinus nigritus* (Howard) (Webster and Phillips 1912, Giles et al. 2003, 2021, Jones et al. 2014, Royer et al. 2015, Elliott et al. 2018). Previous studies in sorghum also documented that *L. testaceipes* was the most abundant aphid parasitoid (Gilstrap et al. 1984). However, since the invasion of the sorghum aphid in 2013, *A. nigritus* has been more regularly found in both sorghum and winter wheat fields (Maxson et al. 2019, Elliott et al. 2021, Giles et al. 2021, Faris, Elliott, et al. 2022). Despite many records of *A. nigritus* in winter wheat and sorghum (Archer et al. 1974, Kring and Gilstrap 1983, Gilstrap et al. 1984, Elliott et al. 2019, 2021, Maxson et al. 2019, Giles et al. 2021, Faris, Brewer, et al. 2022), little information is known about its basic biology and life-history. A degree day model for *A. nigritus* development would aid in predicting its seasonal population dynamics and aphid suppression potential. Seasonal temperatures and pest management recommendations vary significantly with latitude (Royer et al. 2015, Elliott et al. 2021). Hence, the objective of this study was to document relationships between temperature and *A. nigritus* development rate for three developmental stages, eggs, larvae, and pupae. Findings from this study will allow for the calculation of the developmental threshold and summarization of a degree-day model for *A. nigritus.*

Methods

The relationship between temperature and *A. nigritus* development was described for individuals collected from a maintained laboratory colony and directly from sorghum fields. The laboratory colony was established during the summer of 2020 from mummies collected near Hillsboro, Texas, and Hobart and Perkins, Oklahoma, and maintained on S. graminum (Biotype E) infested sorghum ('TX7000') at 24ºC and 16:8 L:D in the laboratory. The laboratory colony was maintained continuously, with new aphids and plants added 2-3 times weekly. Additional *A. nigritus* were added to the colony from the same locations during the summer of 2021 to maintain genetic diversity and overall colony health. Mummies were collected as needed from the colony and held at 24ºC and 16:8 L:D until emergence and initiation of experiments. In addition, *A. nigritus* mummies were collected as needed directly from the same field locations during the summer of 2021 and held at 24ºC and 16:8 L:D until emergence and initiation of experiments.

Five separate experimental replications were conducted to describe the relationship between temperature and *A. nigritus* development; two on wasps from the colony and three on field-collected wasps. Experiments were conducted in environmental chambers, each maintained at a constant temperature and serving as an experimental unit, with individual *A. nigritus* considered as sub-samples.

For each experiment, collected mummies were checked daily. Upon emergence, mating pairs were systematically isolated at experimental temperatures (see below) for 24 hours in a 1.5 mL centrifuge vial containing a small amount of cotton with a 1:3 honey-water solution. Mated pairs were pre-assigned to one of four environmental chambers maintained at constant temperatures and one fixed light-dark cycle: 14, 18, 22, and 26ºC each at 16:8 L:D cycle (Lee and Elliott 1998). After the 24-hour mating period, pairs were introduced into established experimental microcosms at assigned temperatures and briefly observed to ensure that foraging activity was occurring. Microcosms were established 24 hours before introducing the parasitoids. They consisted of plexiglass and mesh-covered Super SC10U 1.5" x 8.25" cone-tainers with one' TX7000' sorghum seedling and 30 *S. graminum* with an even age distribution from early instar to adult. Adult pairs were removed after 24h, and each microcosm was examined daily for mummies. Mummies were isolated in 1.5 mL centrifuge vials and held at the same temperature until adult emergence. A total of 65 pairs were represented in five experimental replications, and 86-303 individual *A. nigritus* were evaluated in each replication. The number of days from oviposition to mummy, mummy to adult, and oviposition to adult were recorded. Each individual's developmental rate (1/days) was calculated for the three described developmental periods (Lee and Elliott 1998).

Simple descriptive statistics were summarized and included 1) mean developmental time + SE from oviposition to mummy, mummy to adult, and oviposition to adult at each temperature, and 2) mean degree-days required (Summed Avg. daily temp – threshold) + SE from oviposition to mummy, mummy to adult, and oviposition to adult at each temperature. The developmental rates for oviposition to mummy, mummy to adult, and oviposition to adult for the subsample individuals in the same experimental replication at each temperature were averaged, resulting in five data points for each temperature. Average developmental rates were then regressed on temperature for each stage (PROC REG) assuming normal distributions using SAS/STAT® software, Version 9.4 for Windows (SAS Institute Inc. © 2014. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute, Cary, NC, USA). The x-intercepts are estimates of developmental thresholds for each stage and were calculated from simple linear regression equations (Lee and Elliott 1998).

Results and Discussion

For each life stage, developmental thresholds were estimated by linear regression (Fig. 1-3) and calculated as 7.5, 10.5, and 9.1ºC for oviposition to mummy, mummy to adult, and oviposition to adult, respectively (Table 1). These developmental thresholds and rates are similar to the ranges reported by Lajeunesse and Johnson (1992) and Lee and Elliott (1998) for the closely related species *A. varipes* and *A. albipodus*. Although the temperature range in which an insect can survive is more expansive than its range of regular activity and non-arrested development (Ratte 1985), temperature thresholds are essential indicators for estimating an insect's survival in its typical geographic range (Li et al. 2021).

Calculated lower developmental thresholds for *A. nigritus* indicate that it can survive and continue to develop in winter wheat habitats during the coldest winter months in the Southern Great Plains. For example, the 15-year average daily high and low temperatures during January for Oklahoma City (35.472910ºN) are 10ºC and -2.22ºC (McPherson et al. 2007), respectively, indicating that degree-days are accumulating during most winters in this region and south into Texas. However, during winter in parts of Kansas, daily maximum temperatures are often too cold for degree-day accumulation and development of *A. nigritus*. In Hays, Kansas (38.8792ºN), the average daily high over the last six years has been 6.7ºC during January (Kansas Mesonet 2022).

Temperatures this low do not support the development of any *A. nigritus* life stage (Table 1).

Developmental times and degree-day requirements for *A. nigritus* varied linearly with temperature (Table 2 and 3, Fig. 1-3), and total development (Oviposition to Adult) ranged from 12.8-45.4 days. Time for development from oviposition to mummy and mummy to adult ranged from 6.5-19 days and 6.3-26.4 days, respectively. Degree-day calculations for each stage and total development were consistent across temperatures, indicating the robust nature of degree-day models (Table 3). On average, the total degree day requirement of *A. nigritus* was 216.15 (Table 3), a value consistent with the related species *A. varipes* and *A. mali*, which were reported to be 204.1 (Yashima and Murai 2012) and 254.8 (Asante and Danthanarayana 1992), respectively.

The degree-day model reported for *A. nigritus* is useful for predicting seasonal population dynamics and co-occurrence with cereal aphids. Sorghum is often grown during dry and hot summers in the Southern Plains region (Hawkins et al. 2017). However, winter weather conditions in the Southern Plains vary significantly with latitude, and dynamics between aphids and *A. nigritus* will primarily depend upon temperature accumulation above developmental thresholds. Indeed, temperature differences along latitudes during the winter may explain why aphid parasitoids are more important biocontrol agents in southern wheat production areas. Rice and Wilde (1988) and Colares et al. (2015) demonstrated that predators, not parasitoids, are more critical natural enemies of aphids in Kansas winter wheat fields infested with aphids. Alternatively, several studies in Oklahoma indicate that parasitoids maintain aphids below economic injury levels in winter wheat, and *A. nigritus* is commonly found during both the fall and spring (Giles et al. 2003, 2008, 2021, Faris, Brewer, et al. 2022, Faris, Elliott, et al. 2022).

Higher winter temperatures alone do not fully explain why aphid parasitoids are more important biocontrol agents in the southern latitudes of the Great Plains. *Aphelinus nigritus* occurs in Kansas (Brewer et al. 2022, Faris, Elliott, et al. 2022), and local populations may be adapted to survive harsh winters instead of maximizing reproduction. For example, *A. nigritus* rapidly colonized sentinel sorghum plants infested with *M. sorghi* in central Kansas (Colares et al. 2015). During these winter months, biotic resources can be scarce, and insects that have adapted variations of an overwintering dormancy strategy would possess a unique ability to thrive in these climates (Langer and Hance 2000). In the northern regions of the Southern Great Plains, aphid parasitoids emerge later during the spring than may be expected based on degree day requirements (Giles et al. 2008). This late emergence may be evidence of a delayed development strategy. Further field investigations and laboratory studies on dormancy are needed to understand *A. nigritus* development under a range of seasonal conditions.

Insects are essentially ectothermic organisms (Beck 1983), and their developmental processes depend on complex chemical reactions, the rates of which are determined mainly by temperature. Laboratory experiments exploring how temperatures influence insect development will be required to understand these fundamental processes (Ratte 1985) and to predict population dynamics (Le Lann et al. 2021). This study described strong linear relationships between temperature and development for *A. nigritus* parasitizing *S. graminum* on sorghum seedlings and is a practical first step in developing parasitoid-aphid population dynamics models. Future studies of *A. nigritus* should evaluate the effects of host size (Avilla and Copland 1987), host feeding behavior (Collier 1995), photoperiod (Prinsloo and du Plessis 2000), diapause induction (Zhang 2016), and sex ratio allocation (Avilla and Copland 1987, Yashima and Murai 2012, Wang et al. 2016, Su et al. 2018) on parasitoid development.

Table 1. Developmental thresholds for three life stages of Aphelinus nigritus *with regression equations relating developmental rate to temperature were calculated from the mean developmental rate at the four temperatures using the means of each treatment (df = 19 in all cases).*

Life Stage	**Regression Equation**	**r^2**	**Estimated Thermal Threshold (ºC)**
Oviposition – mummy formation	y = 0.009x-0.0676	0.9934	7.511
Mummy formation - adult	y = 0.0102x-0.1066	0.9981	10.451
Oviposition - adult	y = 0.0047x-0.0426	0.9994	9.064

Table 2. Mean (+/- SE) number of days required to complete three developmental periods of Aphelinus nigritus *at four temperatures.*

	Temperature (ºC)			
Life Stage	**14**	**18**	**22**	**26**
oviposition – mummy formation	19.0 ± 0.2	10.1 ± 0.1	7.6 ± 0.1	6.5 ± 0.1
mummy formation – adult	26.4 ± 0.2	13.6 ± 0.1	8.8 ± 0.1	6.3 ± 0.1
oviposition - adult	45.4 ± 0.3	23.7 ± 0.2	16.3 ± 0.1	12.8 ± 0.1

Table 3. Mean (+/- SE) total development time for Aphelinus nigritus *at four temperatures and degree-day requirements for three developmental periods Days 1 (oviposition to mummy formation), Days 2 (mummy formation to adult), and Total Days (oviposition to adult).*

Temperature (ºC)	**Total days**	**Degree days 1**	**Degree days 2**	**Total degree days**
14	45.4 ± 0.3	123.2 ± 1.5	93.6 ± 0.7	224.1 ± 1.6
18	23.7 ± 0.2	106.3 ± 1.2	103.0 ± 0.9	212.1 ± 1.6
22	16.3 ± 0.1	110.1 ± 1.2	102.0 ± 1.1	211.1 ± 1.4
26	12.8 ± 0.1	120.5 ± 1.7	98.5 ± 1.2	217.3 ± 1.7
Average	24.6	115.0	99.3	216.15

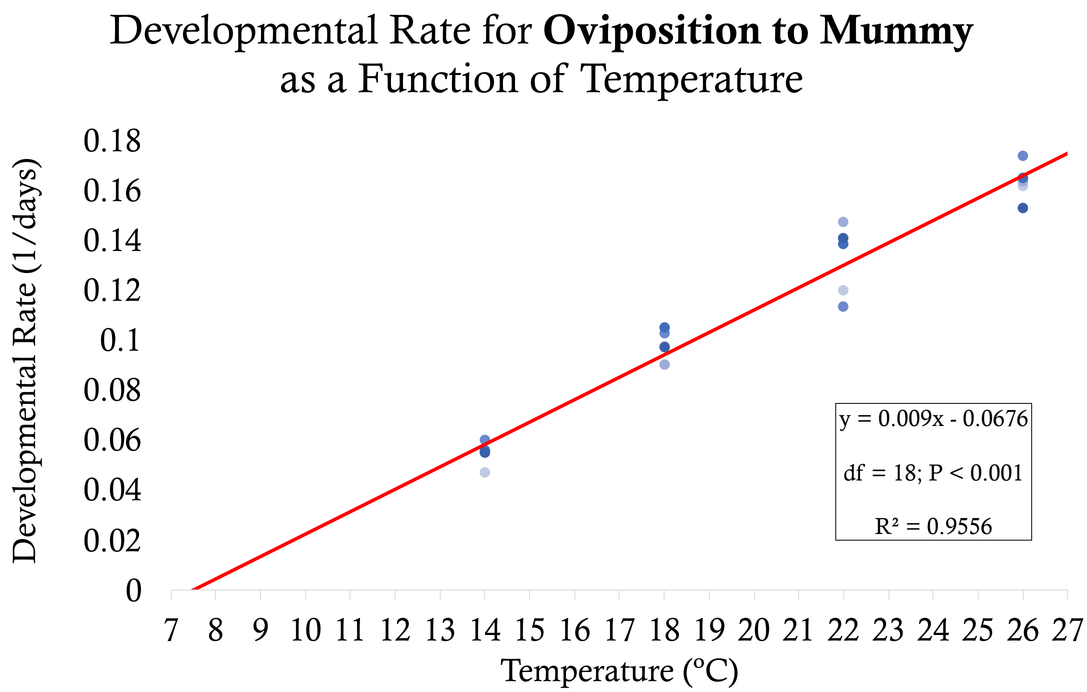

Figure 1. Linear regressions for development rates versus temperature for Aphelinus nigritus oviposition to mummy.

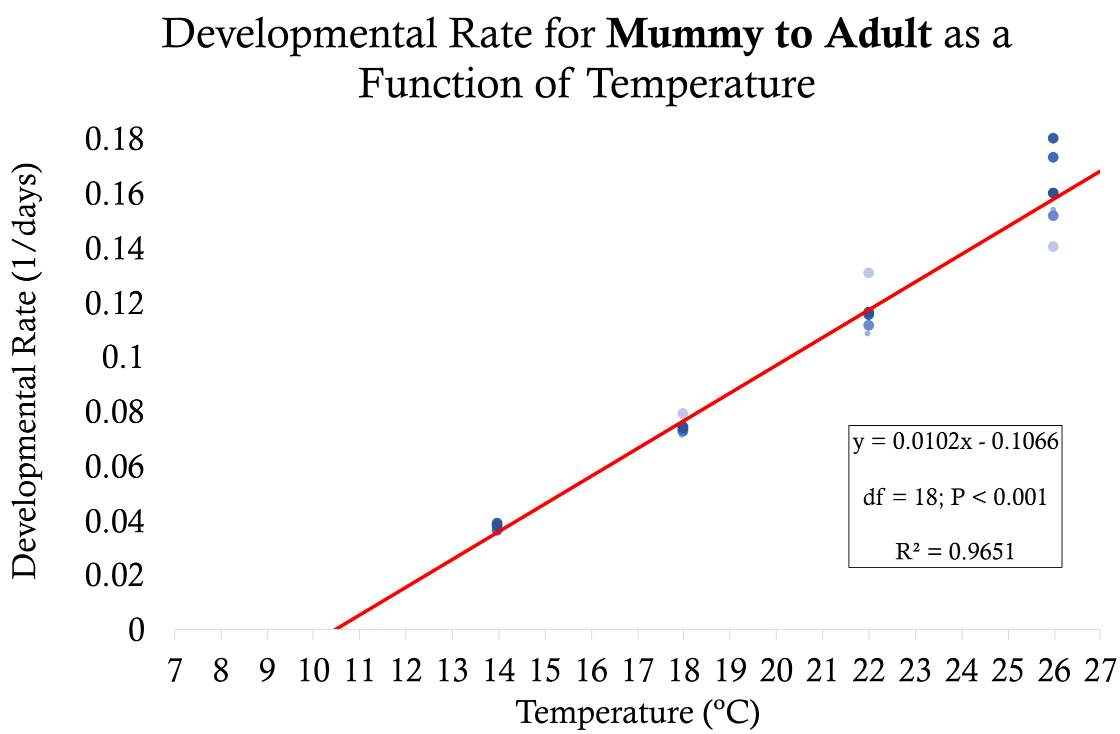

Figure 2. Linear regressions for development rates versus temperature for Aphelinus nigritus mummy to adult.

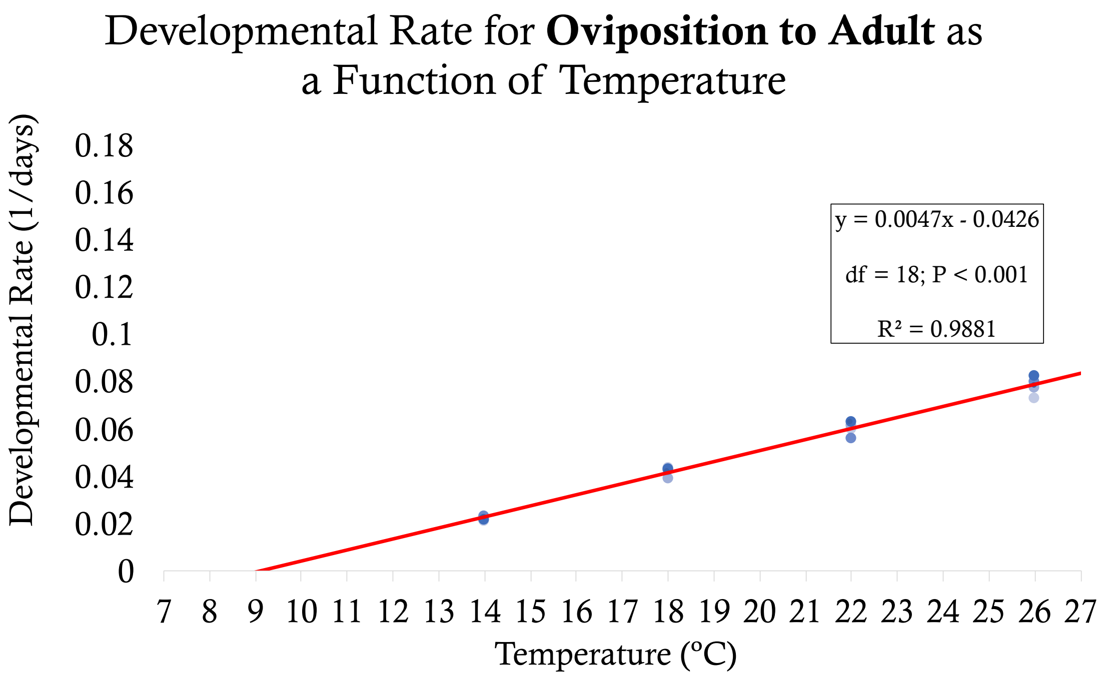

Figure 3. Linear regressions for development rates versus temperature for Aphelinus nigritus oviposition to adult.

CHAPTER 2

Characterizing the Effects of Photoperiod and Temperature on *A. nigritus* Development

Introduction

The Southern Great Plains of North America is a humid, subtropical region that experiences sudden, extreme weather events. Drastic temperature changes challenge poikilotherms, such as insects, and require specific adaptations for survival (Montgomery and MacDonald 1990). Management programs for insect pests in this region require understanding how climate and weather influence the ecology of both pests and their natural enemies, especially in systems where natural enemies provide substantial top-down regulation (Giles et al. 2003, Alyokhin et al. 2011, Brewer et al. 2022).

Winter wheat and sorghum (summer crop) are commonly grown in the U.S. Southern Plains (DeVuyst and Halvorson 2004, Zhang et al. 2017, Elliott et al. 2018), and both are regularly infested with cereal aphids (Butts and Schaalje 1994, Boeve and Weiss 1998, Brewer et al. 2019, Elliott et al. 2021). Greenbug (*Schizaphis graminum* Rondoni) remains a sporadic pest on both crops, with the potential to cause severe damage quickly (Royer et al. 2020, Faris, Brewer, et al. 2022). *Aphelinus* *nigritus* (Howard) (Aphilinidae) is a common parasitoid of greenbug and other aphids in the Southern Plains. It is found regularly on sorghum during the summer (Gilstrap et al. 1984, Maxson et al. 2019) and at low levels on winter wheat (Kring and Gilstrap 1983, Elliott et al. 2019, Giles et al. 2021). *Aphelinus nigritus* has been observed to contribute substantially to cereal aphid mortality in this region (Archer et al. 1974, Gilstrap et al. 1984, Maxson et al. 2019, Brewer et al. 2022, Faris, Brewer, et al. 2022), yet, little is known about its basic life history and ecology (Royer et al. 2015).

In chapter 1, relationships between temperature and the developmental rate of *A. nigritus* were described, and a degree-day model was developed. However, questions remain regarding how seasonal environmental changes, such as temperature and light cycles, influence this species. Historically, *Aphelinus nigritus* seemed to provide insubstantial suppression of aphid pests in the system and was left understudied. With the movement of *M. sorghi* into the system *A. nigritus* can now be found attacking greenbugs year-round in this region. It is particularly abundant during the summer on sorghum and early fall in winter wheat (Elliott et al. 2019, Giles et al. 2021).

Interestingly, results from a recent 3-year field study on winter wheat revealed that *A. nigritus* foraging activity is difficult to detect during early spring, despite relatively high populations the preceding fall (Giles et al. 2021). These results suggest two possibilities for *A. nigritus.* Either they suffer significant mortality during winter or changing hosts, temperature, or photoperiod conditions induce dormancy and delayed development of overwintering stages within aphids.

Winters in the U.S. Southern plains are relatively mild, but extreme lows do occur that approach lethal supercooling points for cereal aphid parasitoids (McPherson et al. 2007, Jones et al. 2008). One possibility is that *A. nigritus* overwinters in an environmentally induced diapause within its host. Reduced temperatures and photoperiods have been shown to induce forms of diapause in other aphilinid parasitoids (Yu 1992, Tatsumi and Takada 2005). Diapause is usually induced via host-by-environment interactions (Polgar and Hardie 2000), and factorial effects of temperature and photoperiod often determine its temporal dynamics. Therefore, we examined how *A. nigritus* development is affected by temperature fluctuations and light cycles typical of the Southern Plains. The primary objective was to test the effects of extreme light cycles and temperatures on *A. nigritus* development for newly emerged adults and their offspring and parasitoid larvae within hosts. I hypothesized that exposure to short day lengths, reinforced by low temperatures, would induce a state of arrested development in *A. nigritus*. We also tested the priming effect of cold storage treatments that simulated prolonged low-temperature events before the imposition of temperature and photoperiod treatments. I hypothesized that 'cold priming' would result in a higher percentage of *A. nigritus* entering a state of arrested development.

Methods

Aphelinus nigritus mummies were collected from Oklahoma sorghum fields from late June 2020 to early September 2020; half were maintained at 24ºC and 14:10 L:D (summer conditions) until emergence, and half were placed into an environmental chamber for a cold priming treatment of 10ºC and 14:10 L:D for 13 days. This cold priming treatment simulated periodic temperature drops typical of the Great Plains winter and was considered a factor in statistical analysis. Following the 13-day priming period, mummies were held at 24ºC and 14:10 L:D until emergence. After emergence, mating pairs from each treatment were isolated in 1.5 mL centrifuge vials with a 1:3 honey: water solution on a cotton ball. After 24 hours, each mated pair was introduced into an experimental microcosm for observation in either of the two experiments (see below). Microcosms were plexiglass and mesh-covered 4-inch pots with three 'TX7000' sorghum seedlings infested with ca. 30 *Schizaphis graminum* (Rodani).

Experiment 1: Exposure of foraging females and their offspring to 3 photoperiods and 2 temperatures

Mating pairs were isolated in microcosms and held under one of six experimental conditions, each combining one of two fluctuating temperature regimes (28-24ºC or 14-10ºC) with one of three photoperiods (15:9 12:12, or 9:15 L:D). Temperatures and photoperiods were selected as representative of winter conditions in Kansas and Oklahoma over the last five years. Adult mating pairs were removed after 24h, and microcosms were examined daily; mummies that formed were isolated in 1.5 mL centrifuge vials and held in the same conditions until emergence. Mummies remaining un-emerged at the end of the experiment were dissected and categorized as containing larva or adult, dead or alive. This experiment was replicated four times, and a total of 557 individuals were evaluated.

Experiment 2: Responses of parasitoid larvae to photoperiod and temperature within their hosts

Aphelinus nigritus pairs were established in microcosms as in Experiment 1 and held at 24ºC and 14:10 L:D until the first mummy was detected so that most mummies contained middle to late-stage *A. nigritus* larvae. Mummies were removed as they formed and placed in each of the six previously described thermal/photoperiodic conditions. The number of days from oviposition to adult was recorded. Any mummies remaining un-emerged at the end of the experiment were dissected and categorized as containing larva or adult, dead or alive. This experiment was replicated five times, and a total of 537 individuals were evaluated.

Statistical Analysis

Degree days (from oviposition to adult) were tallied for each treatment from chapter 1 results. Data from Experiments 1 and 2 were analyzed using generalized linear mixed model methods with 'cold priming' and 'temperature' x 'photoperiod' as independent factors. Variables were analyzed using an exponential distribution, and the number of mummies surviving in each treatment was analyzed using a Poisson distribution. Otherwise, data were analyzed using a normal distribution and means separated using Tukey's test (SAS Institute, 2014) SAS/STAT® software, Version 9.4 for Windows. Total days to adult emergence were compared for this chapter; however, analyses were conducted for days for each stage of development and developmental rates. Complete analysis outputs are presented as an attached appendix.

Results and Discussion

Experiment 1: Exposure of foraging females and their offspring to 3 photoperiods and 2 temperatures

This experiment tested the effects of dramatic environmental changes on adults that do not usually occur in nature (especially day-length changes) but represent manipulations typical of a diapause induction study on insect parasitoids (Röhne 2002, Sengonca et al. 2008). The data set is robust, with 57 maternal *A. nigritus* sources collected in fields over time, and any effects should be considered at least representative of regional populations (Hopper et al. 2019). Summing and analyzing total development time seemed most appropriate because it allows for total lifetime effects to be incorporated into the interpretation.

Significant differences among experimental treatments and significant interaction between cold priming and experimental treatment were detected (Fig. 4, Appendix 1). Interestingly, total development time was longer for all light cycles under cold temperatures than would have been predicted based on the degree day model developed in chapter 1 (Fig. 4). As a significant preliminarily finding, we speculated that *A. nigritus* appeared to be entering diapause in response to cold temperatures. Individuals placed under warm experimental conditions develop as predicted, regardless of previous cold storage. Cold priming was a significant development effect on offspring placed under 10-14ºC conditions at a 12:12 L:D photoperiod. However, all other treatments were unaffected by cold storage (Fig. 4). The lack of adult emergence for many cold temperature treatments, especially under 10-14ºC conditions at the shortest day length (9:15), was concerning. However, dissections revealed development to late pupal/early adult stages. This observation is consistent with the findings of Mansingh (1971) and Tatsumi and Takada (2005), who defined such late-stage dormancy in aphid parasitoids as 'oligopause.'

Experiment 2: Responses of parasitoid larvae to photoperiod and temperature within their hosts

This experiment tested the effects of dramatic environmental changes on larvae within their hosts, which are conditions that generally do not occur in nature (especially day-length changes). Summing and analyzing total development time was complicated since early parasitized aphids were held at warm and long day-length conditions until the first evidence of mummy formation (approximately five days). However, the temperature cycles were realistic (Elliott et al. 2019). With that, total development time is the most appropriate response variable to compare because it allows for total lifetime effects to be considered.

The data set includes 32 maternal *A. nigritus* sources collected in fields over time, and any effects should also be considered at least representative of regional populations

(Hopper et al. 2019). As with experiment 1, significant differences among experimental treatments and significant interaction between cold priming and experimental treatment were detected (Fig. 5, Appendix 1). Total development time was significantly longer for the 15:9 and 9:15 photoperiods under cold temperatures than would be predicted based on the degree day model (Fig. 5). This finding further provides evidence of environmentally induced dormancy. The total development time for the cold temperatures under a 12:12 photoperiod was as predicted but indicated that developing larvae are more sensitive to temperature during the mummy stage than in the larval stage. Cold priming resulted in quicker development in the cold temperature treatments, suggesting that rapid changes in temperature, typical of fall in the Great Plains, can affect subsequent generations and dormancy by delaying emergence times. The effect is likely the outcome of complex host-by-environment interactions outside the scope of this study but meaningful for population dynamics of *A. nigritus* in temperate regions of the Great Plains.

Dissection of mummies that did not emerge revealed nearly fully developed adults, suggesting dormancy induced in the adult stage, possibly adult oligopause. Oligopause is a term proposed by Mansingh (1971) as an intermediate form of dormancy. Tatsumi and Takada (2005) studied the effects of photoperiod and temperature on *A. asychis.* They reported adult oligopause under 10:14 and 15:9 L:D photoperiods, with the transference of mummies from 18ºC to 20ºC causing dormancy to break within 1-2 days. Tatsumi and Takada (2005) concluded that this corresponded to oligopause rather than diapause. We propose that *A. nigritus* enters oligopause in response to low-temperature fluctuations and shorter day lengths that are typical for the colder areas of the Southern Great Plains (Northern Oklahoma and Kansas). However, more research is needed to determine if these effects can be used to improve regional population dynamics models (Koralewski et al. 2020). Future studies should repeat this experiment to determine the warming period required to break dormancy.

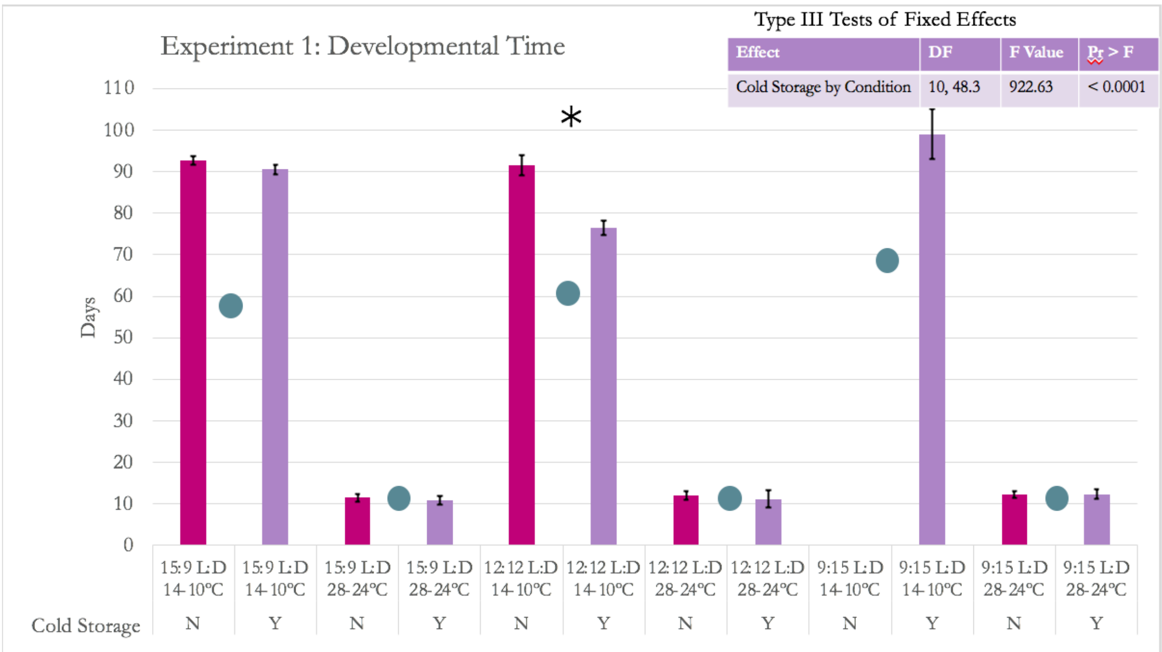

Figure 4*: Effects of changing light cycles and temperatures on newly emerged adults and their offspring. Pink bars represent average developmental time for individuals placed in cold storage for each experiential condition prior to experimentation. Purple bars represent average developmental time for individuals* ***not*** *placed in cold storage prior to experimentation. Blue dots indicated when we would expect emergence under each condition based on degree day models reported in Chapter 1. * indicates experimental conditions that show significantly different developmental times as a result of cold storage effects. SAS PROC GLIMMIX.*

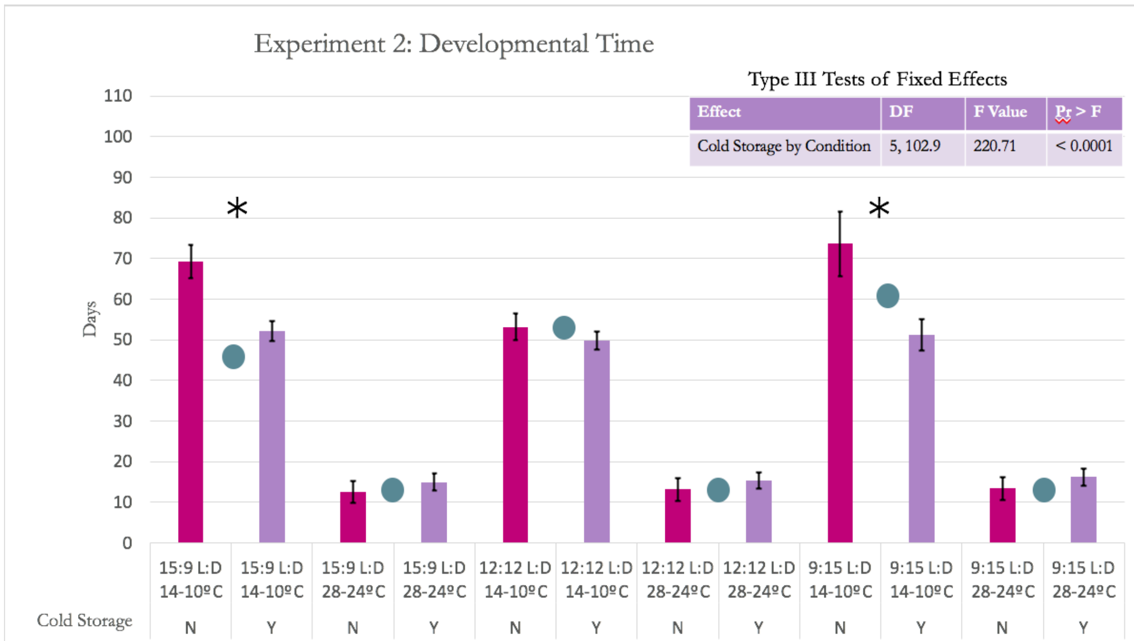

Figure 5*: Effects of changing light cycles and temperatures on parasitoid larvae within hosts. Pink bars represent average developmental time for individuals placed in cold storage for each experiential condition prior to experimentation. Purple bars represent average developmental time for individuals* ***not*** *placed in cold storage prior to experimentation. Blue dots indicated when we would expect emergence under each condition based on degree day models reported in Chapter 1. * indicates experimental conditions that show significantly different developmental times as a result of cold storage effects. SAS PROC GLIMMIX.*

SUMMARY

Understanding how climate and weather influence pests and their natural enemies is significant for making management decisions in agricultural settings. Winter wheat and sorghum are two of the most abundant crops grown in the Southern Great Plains and are home to various pests and their natural enemies. Historically, *Lysiphlebus testaceipes* was the dominant parasitoid associated with aphid pests of these systems. However, with the introduction of sorghum aphids (*Melanaphis sorghi),* a shift in the population dynamics of these systems has been observed. A lesser-studied parasitoid, *Aphelinus nigritus*, has increased in abundance and has been observed to provide substantial pest suppression in sorghum fields. However, very little was known about *A. nigritus* development or how they are able to transition to and survive the cold winter months characteristic of the region.

The first objective of this study was to determine lower developmental thresholds and degree day requirements of *Aphelinus nigritus*. In objective i, microcosms were placed under one of four environmental chambers maintained at constant temperatures and one fixed light-dark cycle: 14, 18, 22, and 26ºC each at 16:8 L:D cycle. The number of days from oviposition to mummy, mummy to adult, and oviposition to adult were recorded, and each individual's developmental rate (1/days) was calculated for the three described developmental periods. Total development (Oviposition to Adult) ranged from

12.8-45.4 days. On average, the total degree day requirement of *A. nigritus* was 216.15 degree days with an average lower developmental threshold of 9.064ºC.

Objective ii was to characterize the effects of photoperiod and temperature on A. nigritus development. In objective ii, microcosms were maintained at one of 6 temperature fluctuation x day length environmental conditions (14-10ºC and 28-24ºC daily fluctuations each at 15:9 L:D, 12:12 L:D, and 9:15 L:D) to assess how these conditions influenced growth and development of offspring. We assessed the effect of parental exposure to environmental change and immature exposure to environmental change. Results indicate that exposure to lower fluctuating temperatures and shorter days cause delays in development greater than those expected for *A. nigritus*. Delayed development associated with the onset of average winter conditions indicates that *A. nigritus* is entering a state of oligopause. Oligopause can be characterized by some growth arrestment, slight and fast biochemical adjustments, and periodic dependence on food. It is generally seen in populations in areas of mild winters or summers (Mansingh 1971, Tatsumi and Takada 2006). However, more research is needed to determine if these effects can be used to improve regional population dynamics models. Future studies should repeat this experiment with an additional warming phase to determine the requirements to break dormancy.

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APPENDICES 1

Days1 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP1
Response Variable	days_from_oviposition_to_mummy__
Response Distribution	Gaussian
Link Function	Identity
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Restricted Maximum Likelihood
Degrees of Freedom Method	Kenward-Roger
Fixed Effects SE Adjustment	Kenward-Roger

Class Level Information		
Class	**Levels**	**Values**
Cold_storage	2	N Y
Experiment_Rep_	4	1 2 3 4
Maternal_Source	57	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57
Experimental_Conditions	6	A B C D E F

Number of Observations Read	557
Number of Observations Used	557

Dimensions	
G-side Cov. Parameters	2
R-side Cov. Parameters	2
Columns in X	12
Columns in Z	61
Subjects (Blocks in V)	1
Max Obs per Subject	557

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	4
Lower Boundaries	4
Upper Boundaries	0

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Days1 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Optimization Information	
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	Restarts	Evaluations	Objective Function	Change	Max Gradient
0	0	4	2536.081639	.	65.71012
1	0	2	2522.0881143	13.99352465	3.381393
2	0	4	2517.6282615	4.45985282	2.746269
3	0	2	2517.291789	0.33647249	2.162816
4	0	4	2517.1397453	0.15204371	0.745015
5	0	4	2517.041463	0.09828228	1.112745
6	0	3	2516.9831772	0.05828582	0.36566
7	0	3	2516.9752288	0.00794841	0.464694
8	0	2	2516.9658623	0.00936644	0.049071
9	0	3	2516.965546	0.00031635	0.004963
10	0	3	2516.9655378	0.00000814	0.000419

Convergence criterion (GCONV=1E-8) satisfied.

Fit Statistics	
-2 Res Log Likelihood	2516.97
AIC (smaller is better)	2524.97
AICC (smaller is better)	2525.04
BIC (smaller is better)	2522.51
CAIC (smaller is better)	2526.51
HQIC (smaller is better)	2519.58
Generalized Chi-Square	546.00
Gener. Chi-Square / DF	1.00

Days1 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

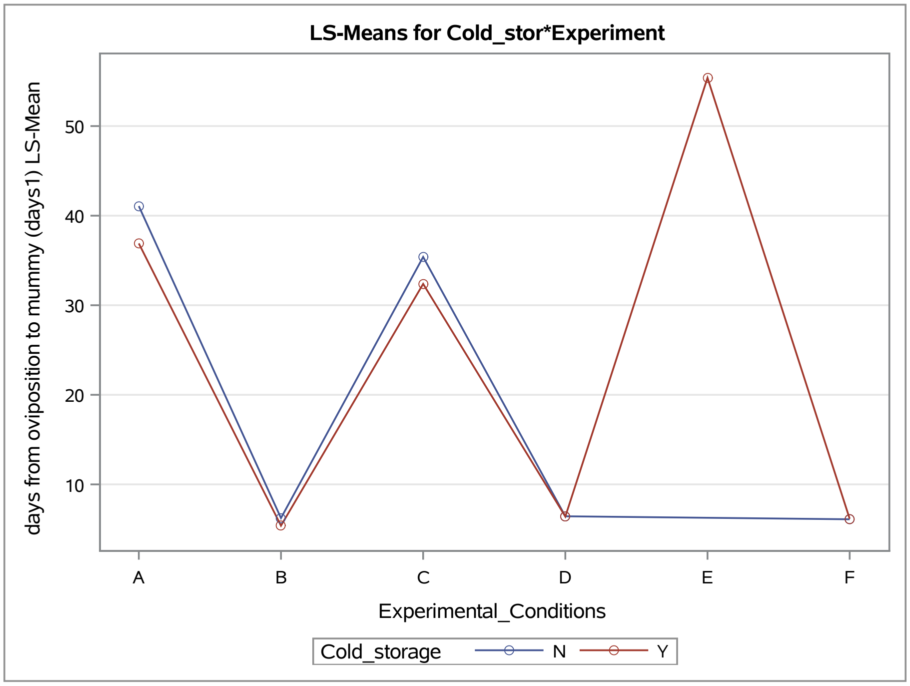
Covariance Parameter Estimates			
Cov Parm	**Group**	**Estimate**	**Standard Error**
Experimen(Cold_stor)		0.7033	1.1337
Exper*Matern(Cold_s)		4.8571	1.4514
Residual (VC)	Cold_storage N	1.8102	0.1805
Residual (VC)	Cold_storage Y	8.3785	0.7050

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Cold_stor*Experiment	10	19.48	227.28	<.0001

Cold_stor*Experiment Least Squares Means						
Cold storage	**Experimental Conditions**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
N	A	41.0719	1.1149	7.499	36.84	<.0001
N	B	6.2422	1.1038	7.225	5.66	0.0007
N	C	35.3908	2.3896	23.13	14.81	<.0001
N	D	6.4387	1.2332	10.81	5.22	0.0003
N	F	6.1061	1.0436	6.331	5.85	0.0009
Y	A	36.9019	1.0402	6.515	35.48	<.0001
Y	B	5.3906	1.0947	7.601	4.92	0.0013
Y	C	32.3832	1.5864	19.72	20.41	<.0001
Y	D	6.4074	1.5211	22.5	4.21	0.0003
Y	E	55.3853	2.1608	42.95	25.63	<.0001
Y	F	6.1627	1.1060	7.755	5.57	0.0006

Days1 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure



T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)				
LS-means with the same letter are not significantly different.				
Cold storage	**Experimental Conditions**	**Estimate**		
Y	E	55.3853		A
N	A	41.0719		B
Y	A	36.9019		C
				C
N	C	35.3908	D	C
			D	
Y	C	32.3832	D	

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Program: \Rudin, Nina\An Analysis.sas

Days1 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)

LS-means with the same letter are not significantly different.

Cold storage	Experimental Conditions	Estimate		
N	D	6.4387		E
				E
Y	D	6.4074		E
				E
N	B	6.2422		E
				E
Y	F	6.1627		E
				E
N	F	6.1061		E
				E
Y	B	5.3906		E

Simple Effect Comparisons of Cold_stor*Experiment Least Squares Means By Experimental_Conditi
Adjustment for Multiple Comparisons: Tukey-Kramer

Simple Effect Level	Cold storage	Cold storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Experimental_Conditi A	N	Y	4.1700	1.5248	7.025	2.73	0.0290	0.0130
Experimental_Conditi B	N	Y	0.8516	1.5546	7.413	0.55	0.5999	0.5900
Experimental_Conditi C	N	Y	3.0075	2.8683	22.95	1.05	0.3053	0.3072
Experimental_Conditi D	N	Y	0.03130	1.9582	16.38	0.02	0.9874	0.9874
Experimental_Conditi F	N	Y	-0.05668	1.5206	7.028	-0.04	0.9713	0.9706

Days2 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP1
Response Variable	Days_from_mummy_to_adult__days2_
Response Distribution	Gaussian
Link Function	Identity
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Restricted Maximum Likelihood
Degrees of Freedom Method	Kenward-Roger
Fixed Effects SE Adjustment	Kenward-Roger

Class Level Information		
Class	**Levels**	**Values**
Cold_storage	2	N Y
Experiment_Rep_	4	1 2 3 4
Maternal_Source	57	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57
Experimental_Conditions	6	A B C D E F

Number of Observations Read	557
Number of Observations Used	408

Dimensions	
G-side Cov. Parameters	2
R-side Cov. Parameters	2
Columns in X	12
Columns in Z	61
Subjects (Blocks in V)	1
Max Obs per Subject	408

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	4
Lower Boundaries	4
Upper Boundaries	0

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Days2 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Optimization Information	
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	**Restarts**	**Evaluations**	**Objective Function**	**Change**	**Max Gradient**
0	**0**	4	2155.5740133	.	12.99357
1	**0**	4	2136.0060569	19.56795631	13.63618
2	**0**	5	2131.4535136	4.55254336	12.44992
3	**0**	2	2123.6433129	7.81020073	1.713513
4	**0**	2	2123.2459998	0.39731305	4.124093
5	**0**	2	2122.7323182	0.51368158	1.192445
6	**0**	3	2122.6002988	0.13201941	0.508753
7	**0**	3	2122.591755	0.00854379	0.044856
8	**0**	3	2122.5916026	0.00015237	0.00466
9	**0**	2	2122.5915768	0.00002588	0.021788

Convergence criterion (GCONV=1E-8) satisfied.

Estimated G matrix is not positive definite.

Fit Statistics	
-2 Res Log Likelihood	2122.59
AIC (smaller is better)	2128.59
AICC (smaller is better)	2128.65
BIC (smaller is better)	2126.75
CAIC (smaller is better)	2129.75
HQIC (smaller is better)	2124.55
Generalized Chi-Square	396.99
Gener. Chi-Square / DF	1.00

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Days2 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Covariance Parameter Estimates

Cov Parm	Group	Estimate	Standard Error
Experimen(Cold_stor)		0	.
Exper*Matern(Cold_s)		5.2795	1.5845
Residual (VC)	Cold_storage N	1.8375	0.2291
Residual (VC)	Cold_storage Y	28.1508	2.6305

Type III Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Cold_stor*Experiment	10	46.46	307.40	<.0001

Cold_stor*Experiment Least Squares Means

Cold storage	Experimental Conditions	Estimate	Standard Error	DF	t Value	Pr > |t|
N	A	51.3155	1.1324	32.81	45.31	<.0001
N	B	5.2228	0.9509	23.53	5.49	<.0001
N	C	57.5000	2.4896	31.17	23.10	<.0001
N	D	5.6059	1.1480	34.58	4.88	<.0001
N	F	6.1117	0.8911	24.72	6.86	<.0001
Y	A	53.9627	1.1578	61.67	46.61	<.0001
Y	B	5.2180	1.0976	45.97	4.75	<.0001
Y	C	46.4130	1.7821	53.48	26.04	<.0001
Y	D	5.2849	2.0113	128.3	2.63	0.0096
Y	E	36.0000	5.7819	230.1	6.23	<.0001
Y	F	6.1609	1.1990	53.59	5.14	<.0001

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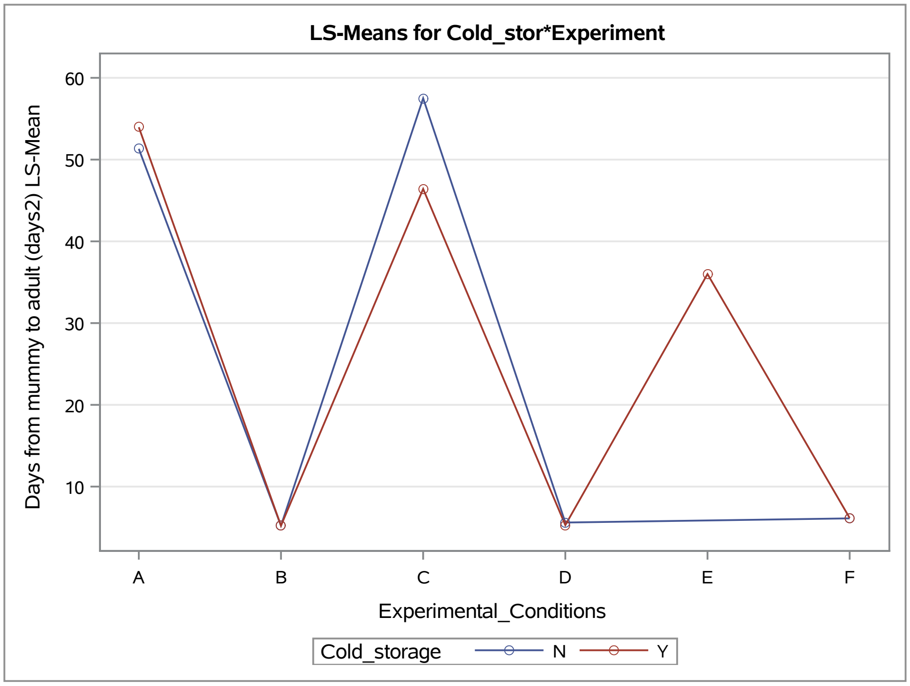
Program: \Rudin, Nina\An Analysis.sas

Days2 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure



T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)				
LS-means with the same letter are not significantly different.				
Cold storage	Experimental Conditions	Estimate		
N	C	57.5000		A
				A
Y	A	53.9627	B	A
			B	
N	A	51.3155	B	
Y	C	46.4130		C
				C
Y	E	36.0000		C

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Days2 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)				
LS-means with the same letter are not significantly different.				
Cold storage	Experimental Conditions	Estimate		
Y	F	6.1609		D
				D
N	F	6.1117		D
				D
N	D	5.6059		D
				D
Y	D	5.2849		D
				D
N	B	5.2228		D
				D
Y	B	5.2180		D

Simple Effect Comparisons of Cold_stor*Experiment Least Squares Means By Experimental_Conditi Adjustment for Multiple Comparisons: Tukey-Kramer								
Simple Effect Level	Cold storage	Cold storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Experimental_Conditi A	N	Y	-2.6472	1.6195	44.75	-1.63	0.1092	0.1089
Experimental_Conditi B	N	Y	0.004810	1.4522	33.69	0.00	0.9974	0.9974
Experimental_Conditi C	N	Y	11.0870	3.0617	37.09	3.62	0.0009	0.0007
Experimental_Conditi D	N	Y	0.3210	2.3159	90.6	0.14	0.8901	0.8904
Experimental_Conditi F	N	Y	-0.04914	1.4938	39.59	-0.03	0.9739	0.9739

Days Total - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP1
Response Variable	Days_from_oviposition_to_adult__
Response Distribution	Gaussian
Link Function	Identity
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Restricted Maximum Likelihood
Degrees of Freedom Method	Kenward-Roger
Fixed Effects SE Adjustment	Kenward-Roger

Class Level Information		
Class	**Levels**	**Values**
Cold_storage	2	N Y
Experiment_Rep_	4	1 2 3 4
Maternal_Source	57	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57
Experimental_Conditions	6	A B C D E F

Number of Observations Read	557
Number of Observations Used	408

Dimensions	
G-side Cov. Parameters	2
R-side Cov. Parameters	2
Columns in X	12
Columns in Z	61
Subjects (Blocks in V)	1
Max Obs per Subject	408

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	4
Lower Boundaries	4
Upper Boundaries	0

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Days Total - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Optimization Information	
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	Restarts	Evaluations	Objective Function	Change	Max Gradient
0	0	4	2149.0311046	.	7.350979
1	0	2	2146.9852048	2.04589975	8.224838
2	0	2	2143.8536104	3.13159435	3.383612
3	0	2	2143.3214346	0.53217581	0.638597
4	0	2	2143.1565889	0.16484579	0.15695
5	0	2	2143.1414937	0.01509518	0.050341
6	0	3	2143.138596	0.00289769	0.04622
7	0	2	2143.1363692	0.00222678	0.028194
8	0	3	2143.135965	0.00040417	0.000527
9	0	3	2143.1359649	0.00000017	9.82E-6

Convergence criterion (GCONV=1E-8) satisfied.

Estimated G matrix is not positive definite.

Fit Statistics	
-2 Res Log Likelihood	2143.14
AIC (smaller is better)	2149.14
AICC (smaller is better)	2149.20
BIC (smaller is better)	2147.29
CAIC (smaller is better)	2150.29
HQIC (smaller is better)	2145.10
Generalized Chi-Square	397.00
Gener. Chi-Square / DF	1.00

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Days Total - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Covariance Parameter Estimates			
Cov Parm	**Group**	**Estimate**	**Standard Error**
Experimen(Cold_stor)		0	.
Exper*Matern(Cold_s)		4.7415	1.4528
Residual (VC)	Cold_storage N	1.8760	0.2284
Residual (VC)	Cold_storage Y	30.8318	2.8985

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Cold_stor*Experiment	10	48.3	922.63	<.0001

Cold_stor*Experiment Least Squares Means						
Cold storage	**Experimental Conditions**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
N	A	92.7012	1.0856	32.45	85.39	<.0001
N	B	11.4603	0.9028	22.71	12.69	<.0001
N	C	91.5000	2.3832	30.83	38.39	<.0001
N	D	12.0127	1.1021	34.3	10.90	<.0001
N	F	12.2306	0.8473	23.97	14.43	<.0001
Y	A	90.6296	1.1459	68.16	79.09	<.0001
Y	B	10.7787	1.0753	49.3	10.02	<.0001
Y	C	76.4878	1.7552	58.56	43.58	<.0001
Y	D	11.2082	2.0356	150.9	5.51	<.0001
Y	E	99.0000	5.9643	244.8	16.60	<.0001
Y	F	12.2714	1.1815	59.86	10.39	<.0001

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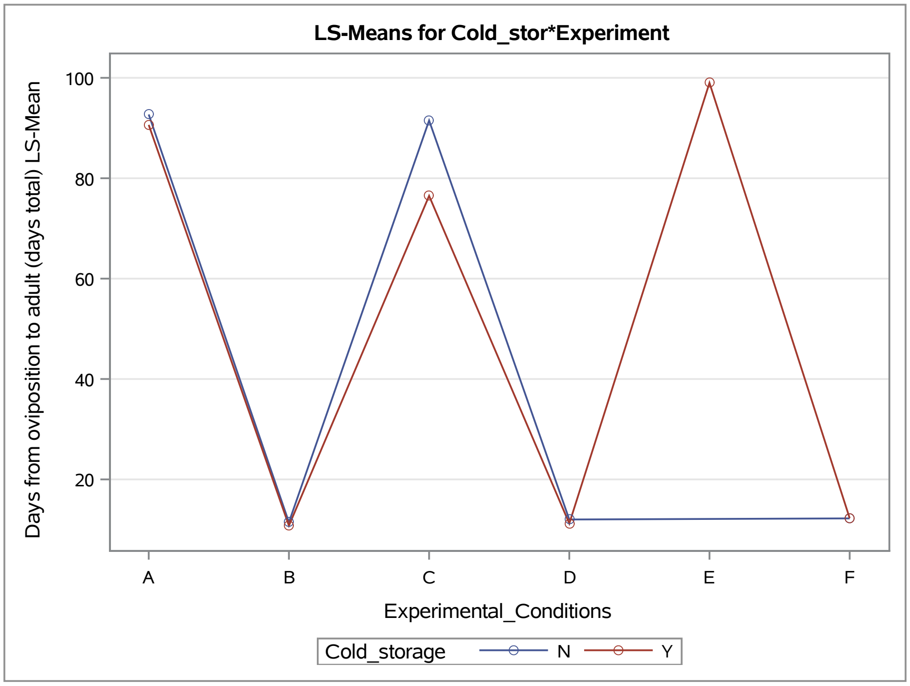
Program: \Rudin, Nina\An Analysis.sas

Days Total - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure



T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)

LS-means with the same letter are not significantly different.

Cold storage	Experimental Conditions	Estimate	
Y	E	99.0000	A
			A
N	A	92.7012	A
			A
N	C	91.5000	A
			A
Y	A	90.6296	A
Y	C	76.4878	B

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Days Total - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Cold storage	Experimental Conditions	Estimate	
Y	F	12.2714	C
			C
N	F	12.2306	C
			C
N	D	12.0127	C
			C
N	B	11.4603	C
			C
Y	D	11.2082	C
			C
Y	B	10.7787	C

Simple Effect Comparisons of Cold_stor*Experiment Least Squares Means By Experimental_Conditi
Adjustment for Multiple Comparisons: Tukey-Kramer

Simple Effect Level	Cold storage	Cold storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Experimental_Conditi A	N	Y	2.0716	1.5785	47.15	1.31	0.1957	0.1956
Experimental_Conditi B	N	Y	0.6815	1.4040	34.68	0.49	0.6304	0.6296
Experimental_Conditi C	N	Y	15.0122	2.9598	38.12	5.07	<.0001	<.0001
Experimental_Conditi D	N	Y	0.8045	2.3148	105.5	0.35	0.7289	0.7297
Experimental_Conditi F	N	Y	-0.04085	1.4539	42.24	-0.03	0.9777	0.9777

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Program: \Rudin, Nina\An Analysis.sas

1/days1 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP1
Response Variable	__days1
Response Distribution	Exponential
Link Function	Log
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Residual PL
Degrees of Freedom Method	Containment

Class Level Information		
Class	Levels	Values
Cold_storage	2	N Y
Experiment_Rep_	4	1 2 3 4
Maternal_Source	57	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57
Experimental_Conditions	6	A B C D E F

Number of Observations Read	557
Number of Observations Used	557

Dimensions	
G-side Cov. Parameters	2
R-side Cov. Parameters	2
Columns in X	12
Columns in Z	61
Subjects (Blocks in V)	1
Max Obs per Subject	557

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	4
Lower Boundaries	4
Upper Boundaries	0

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days1 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Optimization Information	
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	**Restarts**	**Subiterations**	**Objective Function**	**Change**	**Max Gradient**
0	**0**	**10**	-1609.489559	0.98164238	3229.951
1	**0**	**10**	-1086.104595	0.91876243	2170.748
2	**0**	**11**	-854.720143	0.47550599	1832.999
3	**0**	**9**	-757.2045117	0.25075248	1516.72
4	**0**	**6**	-731.6344898	0.06932776	1439.299
5	**0**	**5**	-730.4492941	0.00312635	1435.576
6	**0**	**4**	-730.45437	0.00003438	1435.546
7	**0**	**2**	-730.4542692	0.00001042	1435.538
8	**0**	**1**	-730.4542995	0.00000130	1435.538
9	**0**	**1**	-730.4542943	0.00000084	1435.538
10	**0**	**1**	-730.4542955	0.00000004	1435.538
11	**0**	**1**	-730.4542953	0.00000001	1435.538
12	**0**	**1**	-730.4542953	0.00000009	1435.538
13	**0**	**1**	-730.4542951	0.00000012	1435.538
14	**0**	**1**	-730.4542952	0.00000017	1435.538
15	**0**	**1**	-730.4542949	0.00000000	1435.538

Convergence criterion (PCONV=1.11022E-8) satisfied.

Estimated G matrix is not positive definite.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	-730.45
Generalized Chi-Square	546.00
Gener. Chi-Square / DF	1.00

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days1 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Covariance Parameter Estimates			
Cov Parm	Group	Estimate	Standard Error
Experimen(Cold_stor)		0	.
Exper*Matern(Cold_s)		0.01308	0.003285
Residual (VC)	Cold_storage N	0.009299	0.000926
Residual (VC)	Cold_storage Y	0.01403	0.001153

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Cold_stor*Experiment	10	500	296.71	<.0001

Cold_stor*Experiment Least Squares Means								
Cold storage	Experimental Conditions	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
N	A	-3.7097	0.04909	500	-75.57	<.0001	0.02448	0.001202
N	B	-1.8013	0.04791	500	-37.60	<.0001	0.1651	0.007909
N	C	-3.5611	0.1184	500	-30.08	<.0001	0.02841	0.003363
N	D	-1.8565	0.05911	500	-31.41	<.0001	0.1562	0.009234
N	F	-1.7992	0.04527	500	-39.75	<.0001	0.1654	0.007488
Y	A	-3.5978	0.04296	500	-83.75	<.0001	0.02738	0.001176
Y	B	-1.6953	0.04603	500	-36.83	<.0001	0.1835	0.008449
Y	C	-3.4436	0.07191	500	-47.89	<.0001	0.03195	0.002297
Y	D	-1.8267	0.06756	500	-27.04	<.0001	0.1609	0.01087
Y	E	-3.9744	0.09914	500	-40.09	<.0001	0.01879	0.001863
Y	F	-1.7544	0.04540	500	-38.64	<.0001	0.1730	0.007854

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days1 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)				
LS-means with the same letter are not significantly different.				
Cold storage	Experimental Conditions	Estimate		
Y	B	-1.6953		A
				A
Y	F	-1.7544	B	A
			B	A
N	F	-1.7992	B	A
			B	A
N	B	-1.8013	B	A
			B	A
Y	D	-1.8267	B	A

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days1 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)				
LS-means with the same letter are not significantly different.				
Cold storage	Experimental Conditions	Estimate		
			B	
N	D	-1.8565	B	
Y	C	-3.4436		C
				C
N	C	-3.5611	D	C
			D	C
Y	A	-3.5978	D	C
			D	
N	A	-3.7097	D	
Y	E	-3.9744		E

Simple Effect Comparisons of Cold_stor*Experiment Least Squares Means By Experimental_Conditi Adjustment for Multiple Comparisons: Tukey-Kramer								
Simple Effect Level	Cold storage	Cold storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Experimental_Conditi A	N	Y	-0.1119	0.06523	500	-1.72	0.0869	0.0869
Experimental_Conditi B	N	Y	-0.1060	0.06644	500	-1.60	0.1113	0.1113
Experimental_Conditi C	N	Y	-0.1175	0.1385	500	-0.85	0.3965	0.3965
Experimental_Conditi D	N	Y	-0.02979	0.08977	500	-0.33	0.7401	0.7401
Experimental_Conditi F	N	Y	-0.04480	0.06411	500	-0.70	0.4850	0.4850

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days2 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP1
Response Variable	__days2
Response Distribution	Exponential
Link Function	Log
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Residual PL
Degrees of Freedom Method	Containment

Class Level Information		
Class	**Levels**	**Values**
Cold_storage	2	N Y
Experiment_Rep_	4	1 2 3 4
Maternal_Source	57	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57
Experimental_Conditions	6	A B C D E F

Number of Observations Read	557
Number of Observations Used	408

Dimensions	
G-side Cov. Parameters	2
R-side Cov. Parameters	2
Columns in X	12
Columns in Z	61
Subjects (Blocks in V)	1
Max Obs per Subject	408

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	4
Lower Boundaries	4
Upper Boundaries	0

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days2 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Optimization Information	
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	**Restarts**	**Subiterations**	**Objective Function**	**Change**	**Max Gradient**
0	**0**	**12**	-1034.323416	1.24072623	25594.39
1	**0**	**14**	-686.280244	0.85621408	12294.56
2	**0**	**9**	-560.1698482	0.36794868	8341.255
3	**0**	**10**	-504.3629623	0.29617438	5619.594
4	**0**	**7**	-478.8434155	0.10949604	4737.068
5	**0**	**5**	-476.3761833	0.01159197	4666.113
6	**0**	**4**	-476.3393131	0.00098187	4665.113
7	**0**	**4**	-476.3361326	0.00002804	4665.103
8	**0**	**1**	-476.3360272	0.00000142	4665.103
9	**0**	**0**	-476.3360376	0.00000738	4665.094
10	**0**	**1**	-476.3360592	0.00000688	4665.1
11	**0**	**1**	-476.3360376	0.00000534	4665.096
12	**0**	**1**	-476.3360544	0.00000741	4665.104
13	**0**	**0**	-476.336028	0.00000349	4665.1
14	**0**	**1**	-476.336043	0.00000350	4665.104
15	**0**	**0**	-476.3360297	0.00000277	4665.101
16	**0**	**0**	-476.3360399	0.00000997	4665.113
17	**0**	**1**	-476.336006	0.00000310	4665.109
18	**0**	**1**	-476.3360201	0.00000525	4665.103
19	**0**	**1**	-476.3360362	0.00000007	4665.103

Convergence criterion (PCONV=1E-6) satisfied.

Estimated G matrix is not positive definite.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	-476.34
Generalized Chi-Square	397.00
Gener. Chi-Square / DF	1.00

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days2 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Covariance Parameter Estimates			
Cov Parm	**Group**	**Estimate**	**Standard Error**
Experimen(Cold_stor)		0	.
Exper*Matern(Cold_s)		0.001008	0.000675
Residual (VC)	Cold_storage N	0.03541	0.004174
Residual (VC)	Cold_storage Y	0.009065	0.000854

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Cold_stor*Experiment	10	355	1644.87	<.0001

Cold_stor*Experiment Least Squares Means								
Cold storage	**Experimental Conditions**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Mean**	**Standard Error Mean**
N	A	-3.9436	0.05919	355	-66.62	<.0001	0.01938	0.001147
N	B	-1.6241	0.02493	355	-65.14	<.0001	0.1971	0.004914
N	C	-4.0517	0.1368	355	-29.62	<.0001	0.01739	0.002379
N	D	-1.6639	0.06209	355	-26.80	<.0001	0.1894	0.01176
N	F	-1.8035	0.02757	355	-65.40	<.0001	0.1647	0.004542
Y	A	-3.9703	0.01802	355	-220.27	<.0001	0.01887	0.000340
Y	B	-1.6464	0.01662	355	-99.04	<.0001	0.1927	0.003204
Y	C	-3.8353	0.02741	355	-139.90	<.0001	0.02160	0.000592
Y	D	-1.6578	0.03331	355	-49.76	<.0001	0.1906	0.006348
Y	E	-3.5835	0.1004	355	-35.71	<.0001	0.02778	0.002788
Y	F	-1.8073	0.01852	355	-97.61	<.0001	0.1641	0.003038

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days2 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Conservative T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Cold storage	Experimental Conditions	Estimate	
N	B	-1.6241	A
			A
Y	B	-1.6464	A
			A
Y	D	-1.6578	A
			A
The LINES display does not reflect all significant comparisons. The following additional pairs are significantly different: (Y C,Y A).			

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days2 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Conservative T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Cold storage	Experimental Conditions	Estimate	
N	D	-1.6639	A
N	F	-1.8035	B
			B
Y	F	-1.8073	B
Y	E	-3.5835	C
Y	C	-3.8353	D
			D
N	A	-3.9436	D
			D
Y	A	-3.9703	D
			D
N	C	-4.0517	D
The LINES display does not reflect all significant comparisons. The following additional pairs are significantly different: (Y C,Y A).			

Simple Effect Comparisons of Cold_stor*Experiment Least Squares Means By Experimental_Conditi Adjustment for Multiple Comparisons: Tukey-Kramer								
Simple Effect Level	Cold storage	Cold storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Experimental_Conditi A	N	Y	0.02668	0.06188	355	0.43	0.6666	0.6666
Experimental_Conditi B	N	Y	0.02230	0.02997	355	0.74	0.4572	0.4572
Experimental_Conditi C	N	Y	-0.2164	0.1395	355	-1.55	0.1217	0.1217
Experimental_Conditi D	N	Y	-0.00618	0.07046	355	-0.09	0.9301	0.9301
Experimental_Conditi F	N	Y	0.003797	0.03321	355	0.11	0.9090	0.9090

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days total - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP1
Response Variable	__days_total
Response Distribution	Exponential
Link Function	Log
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Residual PL
Degrees of Freedom Method	Containment

Class Level Information		
Class	**Levels**	**Values**
Cold_storage	2	N Y
Experiment_Rep_	4	1 2 3 4
Maternal_Source	57	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57
Experimental_Conditions	6	A B C D E F

Number of Observations Read	557
Number of Observations Used	408

Dimensions	
G-side Cov. Parameters	2
R-side Cov. Parameters	2
Columns in X	12
Columns in Z	61
Subjects (Blocks in V)	1
Max Obs per Subject	408

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	4
Lower Boundaries	4
Upper Boundaries	0

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days total - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Optimization Information	
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	**Restarts**	**Subiterations**	**Objective Function**	**Change**	**Max Gradient**
0	**0**	**9**	-1826.841991	1.19599895	1.587192
1	**0**	**14**	-1311.209443	1.16448939	4.315052
2	**0**	**12**	-1035.501085	0.70074428	0.389295
3	**0**	**10**	-933.1638152	0.33528941	0.120156
4	**0**	**8**	-880.9278072	0.21650153	0.187431
5	**0**	**8**	-868.0953663	0.05455612	0.128939
6	**0**	**5**	-867.6222132	0.00194332	0.071131
7	**0**	**2**	-867.6209097	0.00014805	0.09811
8	**0**	**3**	-867.6208957	0.00009902	0.006444
9	**0**	**1**	-867.6208953	0.00000017	0.006055

Convergence criterion (PCONV=1E-6) satisfied.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	-867.62
Generalized Chi-Square	397.00
Gener. Chi-Square / DF	1.00

Covariance Parameter Estimates			
Cov Parm	**Group**	**Estimate**	**Standard Error**
Experimen(Cold_stor)		0.000090	0.000459
Exper*Matern(Cold_s)		0.002394	0.000728
Residual (VC)	Cold_storage N	0.006072	0.000725
Residual (VC)	Cold_storage Y	0.004815	0.000457

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days total - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Cold_stor*Experiment	10	355	1261.26	<.0001

Cold_stor*Experiment Least Squares Means								
Cold storage	Experimental Conditions	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
N	A	-4.5261	0.03439	355	-131.61	<.0001	0.01082	0.000372
N	B	-2.4333	0.02296	355	-106.00	<.0001	0.08774	0.002014
N	C	-4.5119	0.07424	355	-60.78	<.0001	0.01098	0.000815
N	D	-2.4745	0.03568	355	-69.35	<.0001	0.08420	0.003005
N	F	-2.4995	0.02261	355	-110.53	<.0001	0.08213	0.001857
Y	A	-4.4976	0.02191	355	-205.23	<.0001	0.01114	0.000244
Y	B	-2.3675	0.02179	355	-108.64	<.0001	0.09372	0.002042
Y	C	-4.3399	0.03368	355	-128.87	<.0001	0.01304	0.000439
Y	D	-2.4185	0.03370	355	-71.76	<.0001	0.08906	0.003002
Y	E	-4.5939	0.08536	355	-53.81	<.0001	0.01011	0.000863
Y	F	-2.5037	0.02340	355	-107.01	<.0001	0.08178	0.001913

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days total - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)

LS-means with the same letter are not significantly different.

Cold storage	Experimental Conditions	Estimate		
Y	B	-2.3675		A
				A
Y	D	-2.4185	B	A
			B	
N	B	-2.4333	B	
			B	
N	D	-2.4745	B	C
				C
N	F	-2.4995		C

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

1/days total - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)				
LS-means with the same letter are not significantly different.				
Cold storage	Experimental Conditions	Estimate		
				C
Y	F	-2.5037		C
Y	C	-4.3399		D
Y	A	-4.4976		E
				E
N	C	-4.5119		E
				E
N	A	-4.5261		E
				E
Y	E	-4.5939		E

Simple Effect Comparisons of Cold_stor*Experiment Least Squares Means By Experimental_Conditi
Adjustment for Multiple Comparisons: Tukey-Kramer

Simple Effect Level	Cold storage	Cold storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Experimental_Conditi A	N	Y	-0.02853	0.04078	355	-0.70	0.4846	0.4846
Experimental_Conditi B	N	Y	-0.06586	0.03165	355	-2.08	0.0382	0.0382
Experimental_Conditi C	N	Y	-0.1720	0.08152	355	-2.11	0.0355	0.0355
Experimental_Conditi D	N	Y	-0.05609	0.04908	355	-1.14	0.2539	0.2539
Experimental_Conditi F	N	Y	0.004268	0.03254	355	0.13	0.8957	0.8957

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Count/Maternal Source for Days1 -- Apparent Parasitism

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP1OUT
Response Variable	days1count
Response Distribution	Poisson
Link Function	Log
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Residual PL
Degrees of Freedom Method	Containment

Class Level Information		
Class	**Levels**	**Values**
Cold_storage	2	N Y
Experiment_Rep_	4	1 2 3 4
Maternal_Source	57	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57
Experimental_Conditions	6	A B C D E F

Number of Observations Read	57
Number of Observations Used	57

Dimensions	
G-side Cov. Parameters	1
Columns in X	12
Columns in Z	4
Subjects (Blocks in V)	1
Max Obs per Subject	57

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	1
Lower Boundaries	1
Upper Boundaries	0
Fixed Effects	Profiled
Starting From	Data

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Count/Maternal Source for Days1 -- Apparent Parasitism

The GLIMMIX Procedure

Iteration History					
Iteration	**Restarts**	**Subiterations**	**Objective Function**	**Change**	**Max Gradient**
0	**0**	**4**	130.23167756	2.00000000	9.996E-6
1	**0**	**3**	158.612862	0.31082088	1.199E-6
2	**0**	**2**	161.64124537	0.00181830	1.055E-7
3	**0**	**1**	161.6732423	0.00001162	1.542E-8
4	**0**	**0**	161.67324708	0.00000000	3.164E-7

Convergence criterion (PCONV=1.11022E-8) satisfied.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	161.67
Generalized Chi-Square	156.03
Gener. Chi-Square / DF	3.39

Covariance Parameter Estimates		
Cov Parm	**Estimate**	**Standard Error**
Experimen(Cold_stor)	0.05773	0.06677

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Cold_stor*Experiment	10	44	8.85	<.0001

Cold_stor*Experiment Least Squares Means								
Cold storage	**Experimental Conditions**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Mean**	**Standard Error Mean**
N	A	1.9825	0.2262	44	8.76	<.0001	7.2612	1.6427
N	B	2.6848	0.2022	44	13.28	<.0001	14.6558	2.9633
N	C	2.1183	0.3650	44	5.80	<.0001	8.3171	3.0362
N	D	0.9028	0.3262	44	2.77	0.0082	2.4666	0.8045
N	F	2.2742	0.2083	44	10.92	<.0001	9.7201	2.0247
Y	A	2.5945	0.1954	44	13.28	<.0001	13.3893	2.6159
Y	B	2.6695	0.1971	44	13.54	<.0001	14.4321	2.8451
Y	C	2.4890	0.2361	44	10.54	<.0001	12.0496	2.8449

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Count/Maternal Source for Days1 -- Apparent Parasitism

The GLIMMIX Procedure

Cold_stor*Experiment Least Squares Means

Cold storage	Experimental Conditions	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
Y	D	1.2445	0.3168	44	3.93	0.0003	3.4713	1.0996
Y	E	1.2445	0.4144	44	3.00	0.0044	3.4713	1.4387
Y	F	2.0553	0.2113	44	9.73	<.0001	7.8089	1.6498

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Count/Maternal Source for Days1 -- Apparent Parasitism

The GLIMMIX Procedure

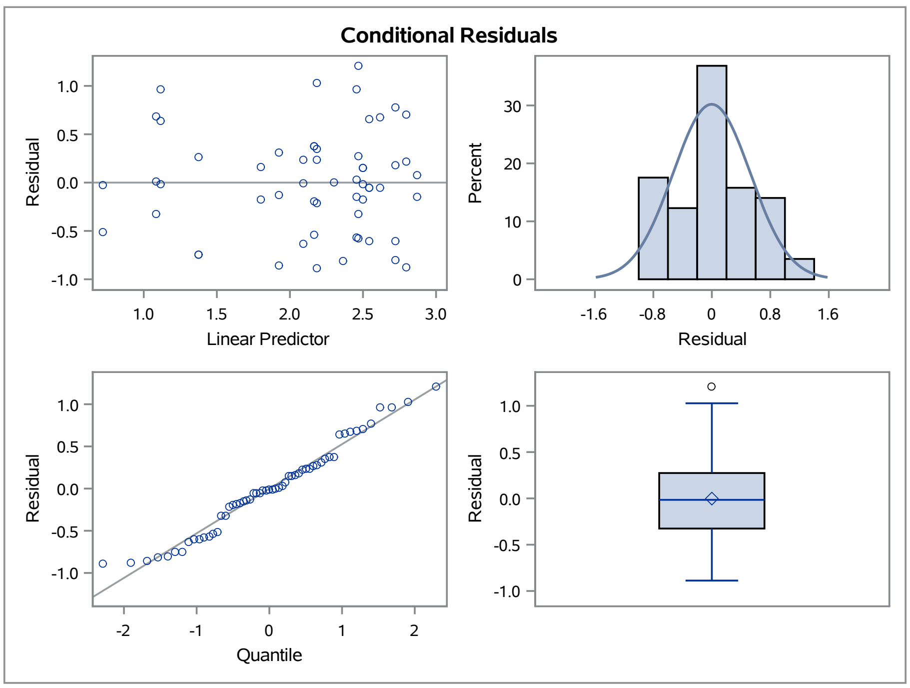
Conservative T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)					
LS-means with the same letter are not significantly different.					
Cold storage	Experimental Conditions	Estimate			
N	B	2.6848		A	
				A	
Y	B	2.6695		A	
				A	
Y	A	2.5945		A	
				A	
Y	C	2.4890	B	A	
			B	A	
N	F	2.2742	B	A	
			B	A	
N	C	2.1183	B	A	C
			B		C
Y	F	2.0553	B		C
			B		C
N	A	1.9825	B		C
					C
Y	D	1.2445		D	C
				D	C
Y	E	1.2445		D	C
				D	
N	D	0.9028		D	
The LINES display does not reflect all significant comparisons. The following additional pairs are significantly different: (N B,N F), (Y C,Y F), (Y F,Y D), (Y F,Y E).					

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Count/Maternal Source for Days1 -- Apparent Parasitism

The GLIMMIX Procedure

Simple Effect Comparisons of Cold_stor*Experiment Least Squares Means By Experimental_Conditi Adjustment for Multiple Comparisons: Tukey-Kramer								
Simple Effect Level	**Cold storage**	**Cold storage**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Adj P**
Experimental_Conditi A	N	Y	-0.6119	0.2989	44	-2.05	0.0466	0.0466
Experimental_Conditi B	N	Y	0.01538	0.2824	44	0.05	0.9568	0.9568
Experimental_Conditi C	N	Y	-0.3707	0.4347	44	-0.85	0.3984	0.3984
Experimental_Conditi D	N	Y	-0.3417	0.4547	44	-0.75	0.4563	0.4563
Experimental_Conditi F	N	Y	0.2189	0.2967	44	0.74	0.4645	0.4645



Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Count/Maternal Source for DaysTotal -- Actual Parasitism

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP1OUT
Response Variable	daystotalcount
Response Distribution	Poisson
Link Function	Log
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Residual PL
Degrees of Freedom Method	Containment

Class Level Information		
Class	**Levels**	**Values**
Cold_storage	2	N Y
Experiment_Rep_	4	1 2 3 4
Maternal_Source	57	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57
Experimental_Conditions	6	A B C D E F

Number of Observations Read	57
Number of Observations Used	57

Dimensions	
G-side Cov. Parameters	1
Columns in X	12
Columns in Z	4
Subjects (Blocks in V)	1
Max Obs per Subject	57

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	1
Lower Boundaries	1
Upper Boundaries	0
Fixed Effects	Profiled
Starting From	Data

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Count/Maternal Source for DaysTotal -- Actual Parasitism

The GLIMMIX Procedure

Iteration History

Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
0	0	5	120.90480438	0.96447340	0.000218
1	0	3	148.37355781	0.10757600	5.918E-6
2	0	2	151.81110762	0.00160749	1.737E-8
3	0	1	151.86283241	0.00001731	2.723E-9
4	0	0	151.86286226	0.00000000	3.656E-7

Convergence criterion (PCONV=1.11022E-8) satisfied.

Fit Statistics

-2 Res Log Pseudo-Likelihood	151.86
Generalized Chi-Square	127.06
Gener. Chi-Square / DF	2.76

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error
Experimen(Cold_stor)	0.07991	0.09055

Type III Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Cold_stor*Experiment	10	44	11.72	<.0001

Cold_stor*Experiment Least Squares Means

Cold storage	Experimental Conditions	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
N	A	0.5393	0.3635	44	1.48	0.1451	1.7147	0.6233
N	B	2.6203	0.2298	44	11.40	<.0001	13.7396	3.1571
N	C	0.5276	0.7387	44	0.71	0.4789	1.6949	1.2520
N	D	0.6472	0.3751	44	1.73	0.0914	1.9102	0.7164
N	F	2.1282	0.2385	44	8.92	<.0001	8.3994	2.0030
Y	A	1.9598	0.2395	44	8.18	<.0001	7.0977	1.7000
Y	B	2.5842	0.2255	44	11.46	<.0001	13.2528	2.9882
Y	C	2.1102	0.2793	44	7.56	<.0001	8.2502	2.3043

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Count/Maternal Source for DaysTotal -- Actual Parasitism

The GLIMMIX Procedure

Cold_stor*Experiment Least Squares Means

Cold storage	Experimental Conditions	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
Y	D	0.9904	0.3620	44	2.74	0.0089	2.6922	0.9745
Y	E	-0.7144	1.0199	44	-0.70	0.4873	0.4895	0.4992
Y	F	1.8750	0.2420	44	7.75	<.0001	6.5206	1.5779

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Count/Maternal Source for DaysTotal -- Actual Parasitism

The GLIMMIX Procedure

Conservative T Grouping for Cold_stor*Experiment Least Squares Means (Alpha=0.05)

LS-means with the same letter are not significantly different.

Cold storage	Experimental Conditions	Estimate			
N	B	2.6203		A	
				A	
Y	B	2.5842		A	
				A	
N	F	2.1282	B	A	
			B	A	
Y	C	2.1102	B	A	C
			B	A	C
Y	A	1.9598	B	A	C
			B		C
Y	F	1.8750	B		C
					C
Y	D	0.9904		D	C
				D	C
N	D	0.6472		D	C
				D	C
N	A	0.5393		D	C
				D	C
N	C	0.5276		D	C
				D	
Y	E	-0.7144		D	

**The LINES display does not reflect all significant comparisons.
The following additional pairs are significantly different: (N B,N F), (Y B,Y C), (Y B,Y A), (Y C,Y D), (Y C,N D), (Y C,N A), (Y A,Y D), (Y A,N D), (Y A,N A), (Y F,Y D), (Y F,N D), (Y F,N A).**

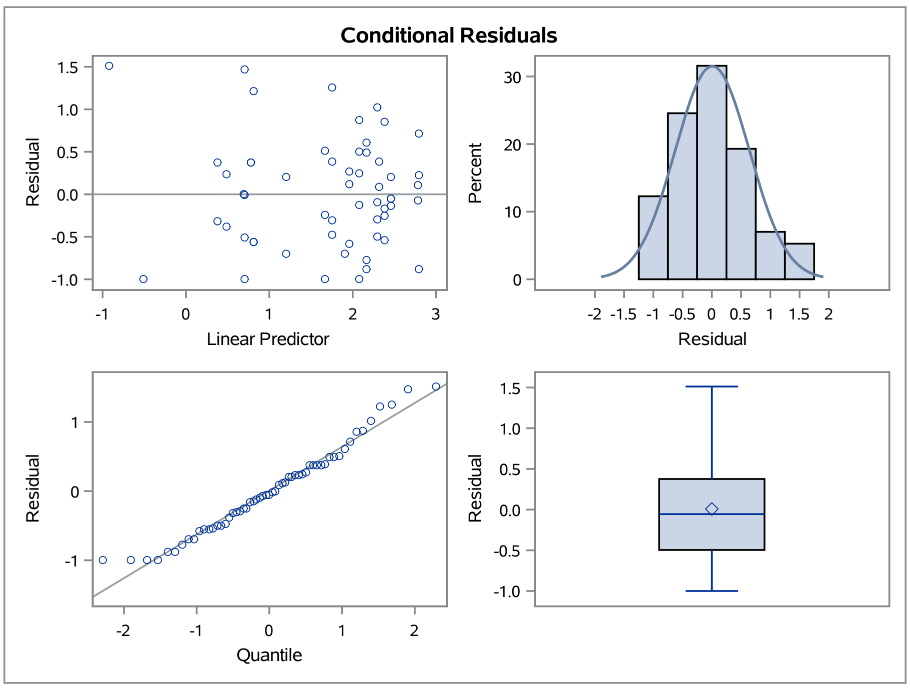
Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas

Count/Maternal Source for DaysTotal -- Actual Parasitism

The GLIMMIX Procedure

Simple Effect Comparisons of Cold_stor*Experiment Least Squares Means By Experimental_Conditi
Adjustment for Multiple Comparisons: Tukey-Kramer

Simple Effect Level	Cold storage	Cold storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Experimental_Conditi A	N	Y	-1.4205	0.4353	44	-3.26	0.0021	0.0021
Experimental_Conditi B	N	Y	0.03607	0.3219	44	0.11	0.9113	0.9113
Experimental_Conditi C	N	Y	-1.5826	0.7897	44	-2.00	0.0513	0.0513
Experimental_Conditi D	N	Y	-0.3431	0.5212	44	-0.66	0.5138	0.5138
Experimental_Conditi F	N	Y	0.2532	0.3397	44	0.75	0.4601	0.4601



APPENDICES 2

Days1 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP2
Response Variable	days_from_oviposition_to_mummy__
Response Distribution	Gaussian
Link Function	Identity
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Restricted Maximum Likelihood
Degrees of Freedom Method	Kenward-Roger
Fixed Effects SE Adjustment	Kenward-Roger

Class Level Information		
Class	**Levels**	**Values**
Cold_Storage	2	N Y
Experiment_Rep_	5	1 2 3 4 5
Maternal_Source	32	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Condition_Moved_To	6	A B C D E F

Number of Observations Read	537
Number of Observations Used	312

Dimensions	
G-side Cov. Parameters	2
R-side Cov. Parameters	1
Columns in X	21
Columns in Z	37
Subjects (Blocks in V)	1
Max Obs per Subject	312

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	2
Lower Boundaries	2
Upper Boundaries	0

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Days1 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Optimization Information	
Fixed Effects	Profiled
Residual Variance	Profiled
Starting From	Data

Iteration History					
Iteration	**Restarts**	**Evaluations**	**Objective Function**	**Change**	**Max Gradient**
0	**0**	4	1227.8316479	.	1.307383
1	**0**	17	1211.8570795	15.97456844	1.041668
2	**0**	4	1211.7131745	0.14390495	0.169215
3	**0**	2	1211.7077118	0.00546269	0.036524
4	**0**	2	1211.7074587	0.00025312	0.001746
5	**0**	2	1211.7074581	0.00000057	0.000017

Convergence criterion (GCONV=1E-8) satisfied.

Estimated G matrix is not positive definite.

Fit Statistics	
-2 Res Log Likelihood	1211.71
AIC (smaller is better)	1215.71
AICC (smaller is better)	1215.75
BIC (smaller is better)	1214.93
CAIC (smaller is better)	1216.93
HQIC (smaller is better)	1213.61
Generalized Chi-Square	706.31
Gener. Chi-Square / DF	2.35

Covariance Parameter Estimates		
Cov Parm	**Estimate**	**Standard Error**
Experimen(Cold_Stor)	0	.
Exper*Matern(Cold_S)	6.1745	1.9700
Residual	2.3544	0.1991

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Days1 - Analysis Variable
Test for the effects of cold storage on all days

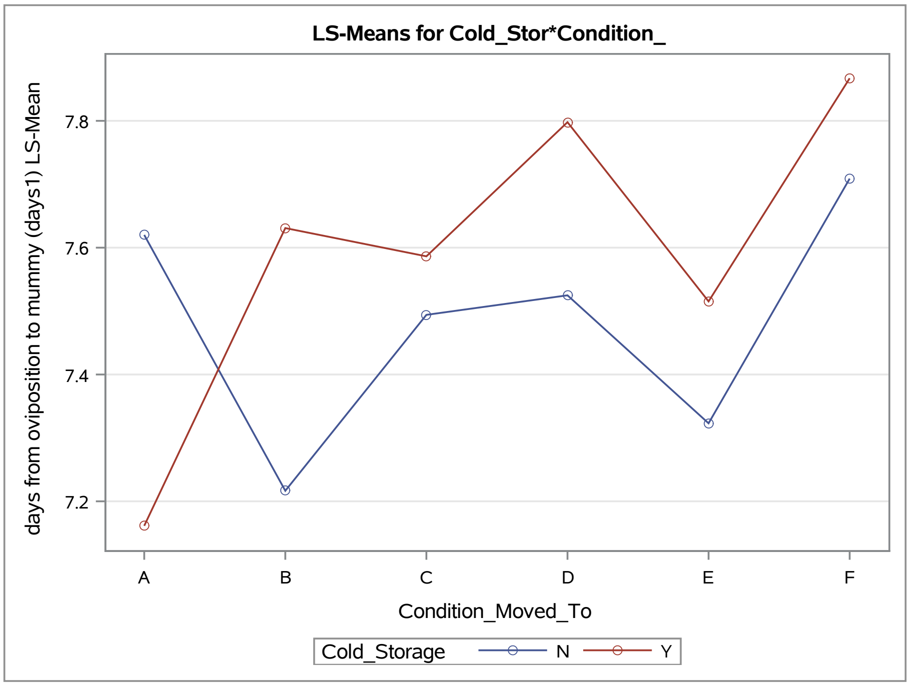
The GLIMMIX Procedure

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Cold_Storage	1	23.42	0.01	0.9177
Condition_Moved_To	5	282.3	0.53	0.7544
Cold_Stor*Condition_	5	282.3	0.48	0.7923

Cold_Stor*Condition_ Least Squares Means						
Cold Storage	**Condition Moved To**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
N	A	7.6201	0.7763	31.23	9.82	<.0001
N	B	7.2167	0.7712	30.45	9.36	<.0001
N	C	7.4940	0.7709	30.41	9.72	<.0001
N	D	7.5249	0.7796	31.65	9.65	<.0001
N	E	7.3231	0.7747	30.96	9.45	<.0001
N	F	7.7089	0.7831	32.24	9.84	<.0001
Y	A	7.1614	0.8434	29.86	8.49	<.0001
Y	B	7.6309	0.8444	30	9.04	<.0001
Y	C	7.5863	0.8424	29.95	9.01	<.0001
Y	D	7.7979	0.8307	28.56	9.39	<.0001
Y	E	7.5153	0.8374	29.25	8.97	<.0001
Y	F	7.8671	0.8426	29.75	9.34	<.0001

Days1 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure



T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Cold Storage	Condition Moved To	Estimate	
Y	F	7.8671	A
			A
Y	D	7.7979	A
			A
N	F	7.7089	A
			A
Y	B	7.6309	A
			A
N	A	7.6201	A

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Days1 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Cold Storage	Condition Moved To	Estimate	
			A
Y	C	7.5863	A
			A
N	D	7.5249	A
			A
Y	E	7.5153	A
			A
N	C	7.4940	A
			A
N	E	7.3231	A
			A
N	B	7.2167	A
			A
Y	A	7.1614	A

Simple Effect Comparisons of Cold_Stor*Condition_ Least Squares Means By Condition_Moved_To Adjustment for Multiple Comparisons: Tukey-Kramer								
Simple Effect Level	Cold Storage	Cold Storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Condition_Moved_To A	N	Y	0.4587	1.1463	30.48	0.40	0.6918	0.6894
Condition_Moved_To B	N	Y	-0.4142	1.1436	30.2	-0.36	0.7197	0.7175
Condition_Moved_To C	N	Y	-0.09228	1.1419	30.16	-0.08	0.9361	0.9356
Condition_Moved_To D	N	Y	-0.2730	1.1392	29.95	-0.24	0.8122	0.8108
Condition_Moved_To E	N	Y	-0.1922	1.1408	30.02	-0.17	0.8673	0.8663
Condition_Moved_To F	N	Y	-0.1582	1.1504	30.87	-0.14	0.8915	0.8907

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Days2 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP2
Response Variable	Days_from_mummy_to_adult__days2_
Response Distribution	Gaussian
Link Function	Identity
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Restricted Maximum Likelihood
Degrees of Freedom Method	Kenward-Roger
Fixed Effects SE Adjustment	Kenward-Roger

Class Level Information		
Class	**Levels**	**Values**
Cold_Storage	2	N Y
Experiment_Rep_	5	1 2 3 4 5
Maternal_Source	32	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Condition_Moved_To	6	A B C D E F

Number of Observations Read	537
Number of Observations Used	187

Dimensions	
G-side Cov. Parameters	2
R-side Cov. Parameters	2
Columns in X	21
Columns in Z	37
Subjects (Blocks in V)	1
Max Obs per Subject	187

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	4
Lower Boundaries	4
Upper Boundaries	0

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Days2 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Optimization Information	
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	Restarts	Evaluations	Objective Function	Change	Max Gradient
0	0	4	1259.4028437	.	0.112188
1	0	2	1259.3719846	0.03085911	0.022293
2	0	3	1259.3614261	0.01055851	0.011168
3	0	2	1259.3579382	0.00348784	0.003439
4	0	2	1259.3575296	0.00040860	0.000219
5	0	2	1259.3575292	0.00000047	0.000017

Convergence criterion (GCONV=1E-8) satisfied.

Fit Statistics	
-2 Res Log Likelihood	1259.36
AIC (smaller is better)	1267.36
AICC (smaller is better)	1267.59
BIC (smaller is better)	1265.80
CAIC (smaller is better)	1269.80
HQIC (smaller is better)	1263.16
Generalized Chi-Square	175.00
Gener. Chi-Square / DF	1.00

Covariance Parameter Estimates			
Cov Parm	Group	Estimate	Standard Error
Experimen(Cold_Stor)		3.8207	5.9134
Exper*Matern(Cold_S)		1.2734	2.6469
Residual (VC)	Cold_Storage N	54.6023	9.5088
Residual (VC)	Cold_Storage Y	72.5524	10.3025

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Days2 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

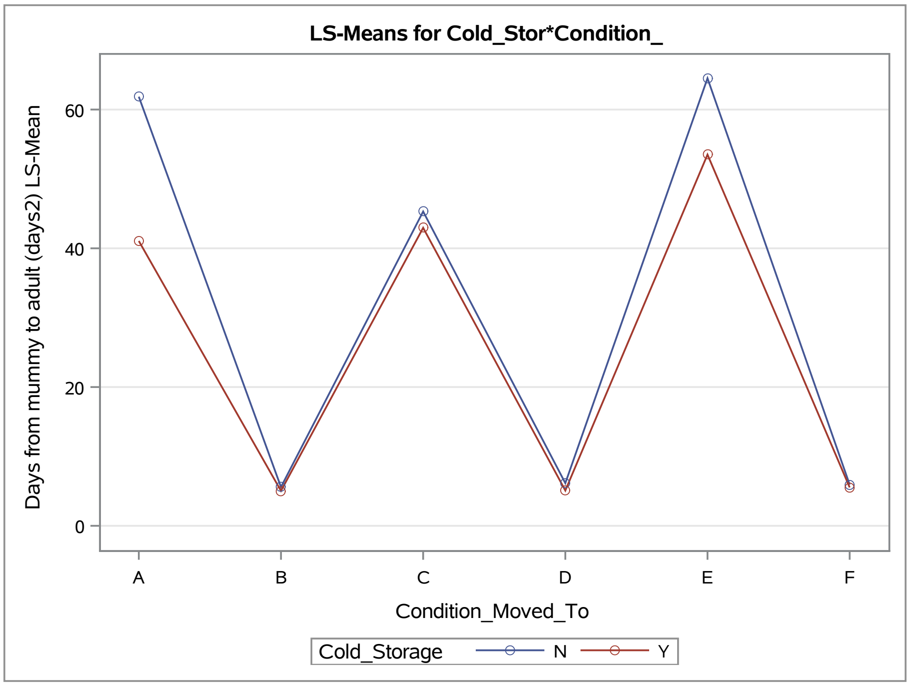
Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Cold_Storage	1	4.635	3.59	0.1211
Condition_Moved_To	5	159.7	165.49	<.0001
Cold_Stor*Condition_	5	159.7	4.12	0.0015

Cold_Stor*Condition_ Least Squares Means						
Cold Storage	**Condition Moved To**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
N	A	61.8555	3.6833	28.4	16.79	<.0001
N	B	5.5829	2.1678	4.937	2.58	0.0503
N	C	45.3031	2.8820	12.02	15.72	<.0001
N	D	6.1485	2.2736	5.914	2.70	0.0359
N	E	64.5074	7.7288	67.61	8.35	<.0001
N	F	5.9348	2.2197	5.288	2.67	0.0417
Y	A	41.0559	3.2612	14.97	12.59	<.0001
Y	B	5.0321	2.3760	5.288	2.12	0.0847
Y	C	42.9533	2.6974	9.395	15.92	<.0001
Y	D	5.0850	2.3235	5.168	2.19	0.0785
Y	E	53.5059	8.8435	100.1	6.05	<.0001
Y	F	5.5313	2.2591	4.681	2.45	0.0614

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Days2 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure



T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)				
LS-means with the same letter are not significantly different.				
Cold Storage	**Condition Moved To**	**Estimate**		
N	E	64.5074		A
				A
N	A	61.8555		A
				A
Y	E	53.5059	B	A
			B	
N	C	45.3031	B	
			B	
Y	C	42.9533	B	

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Days2 - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)				
LS-means with the same letter are not significantly different.				
Cold Storage	**Condition Moved To**	**Estimate**		
			B	
Y	A	41.0559	B	
N	D	6.1485		C
				C
N	F	5.9348		C
				C
N	B	5.5829		C
				C
Y	F	5.5313		C
				C
Y	D	5.0850		C
				C
Y	B	5.0321		C

Simple Effect Comparisons of Cold_Stor*Condition_ Least Squares Means By Condition_Moved_To
Adjustment for Multiple Comparisons: Tukey-Kramer

Simple Effect Level	Cold Storage	Cold Storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Condition_Moved_To A	N	Y	20.7996	4.9196	23.46	4.23	0.0003	<.0001
Condition_Moved_To B	N	Y	0.5508	3.2163	5.169	0.17	0.8705	0.8642
Condition_Moved_To C	N	Y	2.3498	3.9474	11.06	0.60	0.5636	0.5525
Condition_Moved_To D	N	Y	1.0636	3.2508	5.591	0.33	0.7554	0.7440
Condition_Moved_To E	N	Y	11.0016	11.7448	154.4	0.94	0.3504	0.3503
Condition_Moved_To F	N	Y	0.4036	3.1671	5.021	0.13	0.9036	0.8988

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Days Total - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP2
Response Variable	Days_from_oviposition_to_adult__
Response Distribution	Gaussian
Link Function	Identity
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Restricted Maximum Likelihood
Degrees of Freedom Method	Kenward-Roger
Fixed Effects SE Adjustment	Kenward-Roger

Class Level Information		
Class	Levels	Values
Cold_Storage	2	N Y
Experiment_Rep_	5	1 2 3 4 5
Maternal_Source	32	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Condition_Moved_To	6	A B C D E F

Number of Observations Read	537
Number of Observations Used	301

Dimensions	
G-side Cov. Parameters	2
R-side Cov. Parameters	2
Columns in X	21
Columns in Z	37
Subjects (Blocks in V)	1
Max Obs per Subject	301

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	4
Lower Boundaries	4
Upper Boundaries	0

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Days Total - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure

Optimization Information	
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	**Restarts**	**Evaluations**	**Objective Function**	**Change**	**Max Gradient**
0	**0**	4	1994.936367	.	0.576474
1	**0**	4	1993.994591	0.94177603	0.169679
2	**0**	2	1993.7019338	0.29265722	0.130656
3	**0**	2	1993.6353472	0.06658653	0.045272
4	**0**	4	1993.5872257	0.04812152	0.009809
5	**0**	2	1993.585808	0.00141775	0.001337
6	**0**	3	1993.5857571	0.00005091	0.000182
7	**0**	3	1993.5857567	0.00000031	0.000075

Convergence criterion (GCONV=1E-8) satisfied.

Fit Statistics	
-2 Res Log Likelihood	1993.59
AIC (smaller is better)	2001.59
AICC (smaller is better)	2001.73
BIC (smaller is better)	2000.02
CAIC (smaller is better)	2004.02
HQIC (smaller is better)	1997.39
Generalized Chi-Square	288.99
Gener. Chi-Square / DF	1.00

Covariance Parameter Estimates			
Cov Parm	**Group**	**Estimate**	**Standard Error**
Experimen(Cold_Stor)		8.1174	8.9412
Exper*Matern(Cold_S)		4.9064	3.0596
Residual (VC)	Cold_Storage N	54.5903	9.6488
Residual (VC)	Cold_Storage Y	46.3299	4.5802

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Days Total - Analysis Variable
Test for the effects of cold storage on all days

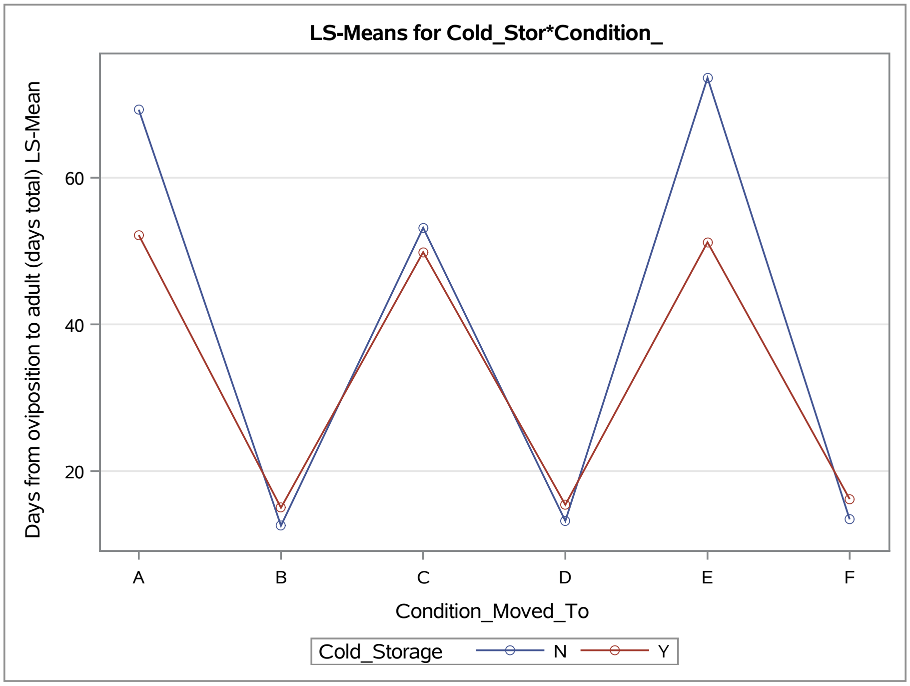
The GLIMMIX Procedure

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Cold_Storage	1	4.074	3.20	0.1470
Condition_Moved_To	5	102.9	220.71	<.0001
Cold_Stor*Condition_	5	102.9	6.68	<.0001

Cold_Stor*Condition_ Least Squares Means						
Cold Storage	**Condition Moved To**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
N	A	69.2647	4.0210	21.12	17.23	<.0001
N	B	12.5547	2.6882	5.151	4.67	0.0051
N	C	53.1749	3.2711	10.22	16.26	<.0001
N	D	13.2054	2.7824	5.88	4.75	0.0033
N	E	73.6120	7.9298	64.98	9.28	<.0001
N	F	13.4205	2.7402	5.511	4.90	0.0034
Y	A	52.1677	2.4001	6.897	21.74	<.0001
Y	B	15.0028	2.0451	3.704	7.34	0.0025
Y	C	49.8455	2.1797	4.836	22.87	<.0001
Y	D	15.4052	2.0202	3.555	7.63	0.0025
Y	E	51.1946	3.9626	45.49	12.92	<.0001
Y	F	16.1783	2.0213	3.576	8.00	0.0021

Days Total - Analysis Variable
Test for the effects of cold storage on all days

The GLIMMIX Procedure



T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Cold Storage	Condition Moved To	Estimate	
N	E	73.6120	A
			A
N	A	69.2647	A
N	C	53.1749	B
			B
Y	A	52.1677	B
			B
Y	E	51.1946	B

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Test for the effects of cold storage on all days

The GLIMMIX Procedure

T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Cold Storage	**Condition Moved To**	**Estimate**	
			B
Y	C	49.8455	B
Y	F	16.1783	C
			C
Y	D	15.4052	C
			C
Y	B	15.0028	C
			C
N	F	13.4205	C
			C
N	D	13.2054	C
			C
N	B	12.5547	C

Simple Effect Comparisons of Cold_Stor*Condition_ Least Squares Means By Condition_Moved_To Adjustment for Multiple Comparisons: Tukey-Kramer								
Simple Effect Level	**Cold Storage**	**Cold Storage**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Adj P**
Condition_Moved_To A	N	Y	17.0971	4.6828	15.41	3.65	0.0023	0.0004
Condition_Moved_To B	N	Y	-2.4481	3.3777	4.554	-0.72	0.5041	0.4702
Condition_Moved_To C	N	Y	3.3294	3.9308	7.968	0.85	0.4217	0.3990
Condition_Moved_To D	N	Y	-2.1998	3.4385	4.896	-0.64	0.5511	0.5237
Condition_Moved_To E	N	Y	22.4174	8.8648	76.92	2.53	0.0135	0.0130
Condition_Moved_To F	N	Y	-2.7578	3.4050	4.7	-0.81	0.4570	0.4199

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days1 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP2
Response Variable	__days1
Response Distribution	Exponential
Link Function	Log
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Residual PL
Degrees of Freedom Method	Containment

Class Level Information		
Class	Levels	Values
Cold_Storage	2	N Y
Experiment_Rep_	5	1 2 3 4 5
Maternal_Source	32	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Condition_Moved_To	6	A B C D E F

Number of Observations Read	537
Number of Observations Used	312

Dimensions	
G-side Cov. Parameters	2
R-side Cov. Parameters	2
Columns in X	21
Columns in Z	37
Subjects (Blocks in V)	1
Max Obs per Subject	312

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	4
Lower Boundaries	4
Upper Boundaries	0

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days1 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Optimization Information	
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	**Restarts**	**Subiterations**	**Objective Function**	**Change**	**Max Gradient**
0	**0**	**11**	-535.2633418	1.01355552	235.0588
1	**0**	**13**	-224.0879855	0.99833431	112.5402
2	**0**	**9**	-97.32334901	0.46004639	91.35648
3	**0**	**7**	-77.50704201	0.09071005	89.72392
4	**0**	**4**	-76.884391	0.00534784	89.68653
5	**0**	**3**	-76.88160898	0.00020199	89.68525
6	**0**	**1**	-76.8817011	0.00000844	89.68527
7	**0**	**1**	-76.88170278	0.00000059	89.68526
8	**0**	**1**	-76.88170288	0.00000018	89.68526
9	**0**	**1**	-76.88170271	0.00000000	89.68526

Convergence criterion (PCONV=1.11022E-8) satisfied.

Estimated G matrix is not positive definite.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	-76.88
Generalized Chi-Square	300.00
Gener. Chi-Square / DF	1.00

Covariance Parameter Estimates			
Cov Parm	**Group**	**Estimate**	**Standard Error**
Experimen(Cold_Stor)		0	.
Exper*Matern(Cold_S)		0.08578	0.02745
Residual (VC)	Cold_Storage N	0.02681	0.003518
Residual (VC)	Cold_Storage Y	0.03642	0.004030

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days1 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

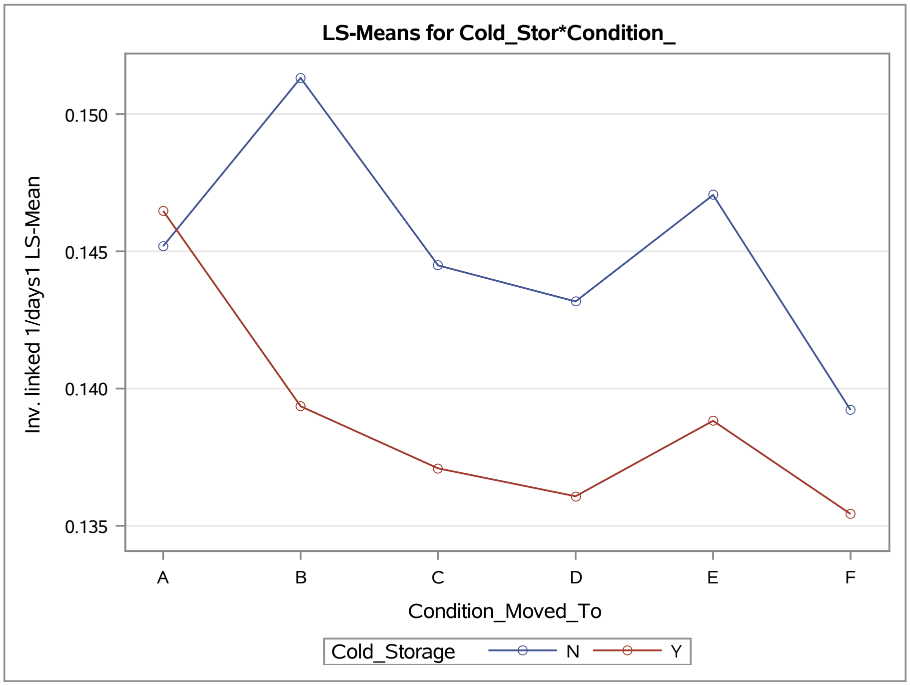
The GLIMMIX Procedure

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Cold_Storage	1	2	0.12	0.7623
Condition_Moved_To	5	278	0.88	0.4948
Cold_Stor*Condition_	5	278	0.39	0.8553

Cold_Stor*Condition_ Least Squares Means								
Cold Storage	Condition Moved To	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
N	A	-1.9297	0.08974	278	-21.50	<.0001	0.1452	0.01303
N	B	-1.8884	0.08924	278	-21.16	<.0001	0.1513	0.01350
N	C	-1.9346	0.08920	278	-21.69	<.0001	0.1445	0.01289
N	D	-1.9437	0.09006	278	-21.58	<.0001	0.1432	0.01289
N	E	-1.9170	0.08958	278	-21.40	<.0001	0.1471	0.01317
N	F	-1.9717	0.09040	278	-21.81	<.0001	0.1392	0.01259
Y	A	-1.9209	0.1003	278	-19.15	<.0001	0.1465	0.01469
Y	B	-1.9707	0.1004	278	-19.62	<.0001	0.1394	0.01400
Y	C	-1.9871	0.1002	278	-19.83	<.0001	0.1371	0.01374
Y	D	-1.9945	0.09874	278	-20.20	<.0001	0.1361	0.01344
Y	E	-1.9745	0.09957	278	-19.83	<.0001	0.1388	0.01382
Y	F	-1.9993	0.1002	278	-19.95	<.0001	0.1354	0.01357

1/days1 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure



T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Cold Storage	Condition Moved To	Estimate	
N	B	-1.8884	A
			A
N	E	-1.9170	A
			A
Y	A	-1.9209	A
			A
N	A	-1.9297	A
			A
N	C	-1.9346	A

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days1 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Cold Storage	Condition Moved To	Estimate	
			A
N	D	-1.9437	A
			A
Y	B	-1.9707	A
			A
N	F	-1.9717	A
			A
Y	E	-1.9745	A
			A
Y	C	-1.9871	A
			A
Y	D	-1.9945	A
			A
Y	F	-1.9993	A

Simple Effect Comparisons of Cold_Stor*Condition_ Least Squares Means By Condition_Moved_To Adjustment for Multiple Comparisons: Tukey-Kramer								
Simple Effect Level	Cold Storage	Cold Storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Condition_Moved_To A	N	Y	-0.00880	0.1346	278	-0.07	0.9479	0.9479
Condition_Moved_To B	N	Y	0.08237	0.1344	278	0.61	0.5403	0.5403
Condition_Moved_To C	N	Y	0.05254	0.1342	278	0.39	0.6956	0.6956
Condition_Moved_To D	N	Y	0.05085	0.1336	278	0.38	0.7039	0.7039
Condition_Moved_To E	N	Y	0.05758	0.1339	278	0.43	0.6676	0.6676
Condition_Moved_To F	N	Y	0.02759	0.1350	278	0.20	0.8382	0.8382

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days2 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP2
Response Variable	__days2
Response Distribution	Exponential
Link Function	Log
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Residual PL
Degrees of Freedom Method	Containment

Class Level Information		
Class	Levels	Values
Cold_Storage	2	N Y
Experiment_Rep_	5	1 2 3 4 5
Maternal_Source	32	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Condition_Moved_To	6	A B C D E F

Number of Observations Read	537
Number of Observations Used	187

Dimensions	
G-side Cov. Parameters	2
R-side Cov. Parameters	2
Columns in X	21
Columns in Z	37
Subjects (Blocks in V)	1
Max Obs per Subject	187

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	4
Lower Boundaries	4
Upper Boundaries	0

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days2 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Optimization Information	
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
0	**0**	**19**	8.0763265273	2.00000000	0.038391
1	**0**	**12**	143.77311596	1.54275987	0.002006
2	**0**	**12**	183.76639993	2.00000000	0.000915
3	**0**	**9**	195.7543181	2.00000000	0.000906
4	**0**	**7**	200.94012977	2.00000000	0.033408
5	**0**	**6**	201.66524957	0.07023593	0.000013
6	**0**	**5**	201.65104926	0.00409232	0.000013
7	**0**	**5**	201.65333739	0.00042642	0.000546
8	**0**	**3**	201.65323424	0.00003817	0.001055
9	**0**	**5**	201.6533142	0.00000573	0.000069

Convergence criterion (PCONV=0.00001) satisfied.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	201.65
Generalized Chi-Square	175.00
Gener. Chi-Square / DF	1.00

Covariance Parameter Estimates			
Cov Parm	Group	Estimate	Standard Error
Experimen(Cold_Stor)		0.002998	0.006330
Exper*Matern(Cold_S)		0.003679	0.006318
Residual (VC)	Cold_Storage N	0.04675	0.008917
Residual (VC)	Cold_Storage Y	0.3302	0.04557

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days2 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Cold_Storage	1	2	1.87	0.3050
Condition_Moved_To	5	154	183.95	<.0001
Cold_Stor*Condition_	5	154	0.70	0.6219

Condition_Moved_To Least Squares Means							
Condition Moved To	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
A	-3.8263	0.1068	154	-35.81	<.0001	0.02179	0.002328
B	-1.6365	0.06932	154	-23.61	<.0001	0.1947	0.01349
C	-3.7223	0.08679	154	-42.89	<.0001	0.02418	0.002099
D	-1.6171	0.06952	154	-23.26	<.0001	0.1985	0.01380
E	-4.0787	0.3111	154	-13.11	<.0001	0.01693	0.005266
F	-1.6411	0.06692	154	-24.52	<.0001	0.1938	0.01297

Differences of Condition_Moved_To Least Squares Means Adjustment for Multiple Comparisons: Tukey-Kramer							
Condition Moved To	Condition Moved To	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
A	B	-2.1898	0.1169	154	-18.74	<.0001	<.0001
A	C	-0.1041	0.1280	154	-0.81	0.4176	0.9648
A	D	-2.2092	0.1176	154	-18.78	<.0001	<.0001
A	E	0.2524	0.3251	154	0.78	0.4387	0.9711
A	F	-2.1852	0.1158	154	-18.87	<.0001	<.0001
B	C	2.0857	0.1006	154	20.74	<.0001	<.0001
B	D	-0.01944	0.08601	154	-0.23	0.8215	0.9999
B	E	2.4422	0.3151	154	7.75	<.0001	<.0001
B	F	0.004604	0.08365	154	0.06	0.9562	1.0000
C	D	-2.1052	0.1009	154	-20.86	<.0001	<.0001
C	E	0.3565	0.3190	154	1.12	0.2656	0.8736
C	F	-2.0811	0.09912	154	-21.00	<.0001	<.0001
D	E	2.4616	0.3152	154	7.81	<.0001	<.0001

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Differences of Condition_Moved_To Least Squares Means Adjustment for Multiple Comparisons: Tukey-Kramer							
Condition Moved To	Condition Moved To	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
D	F	0.02404	0.08411	154	0.29	0.7754	0.9997
E	F	-2.4376	0.3146	154	-7.75	<.0001	<.0001

Tukey-Kramer Grouping for Condition_Moved_To Least Squares Means (Alpha=0.05)		
LS-means with the same letter are not significantly different.		
Condition Moved To	Estimate	
D	-1.6171	A
		A
B	-1.6365	A
		A
F	-1.6411	A
C	-3.7223	B
		B
A	-3.8263	B
		B
E	-4.0787	B

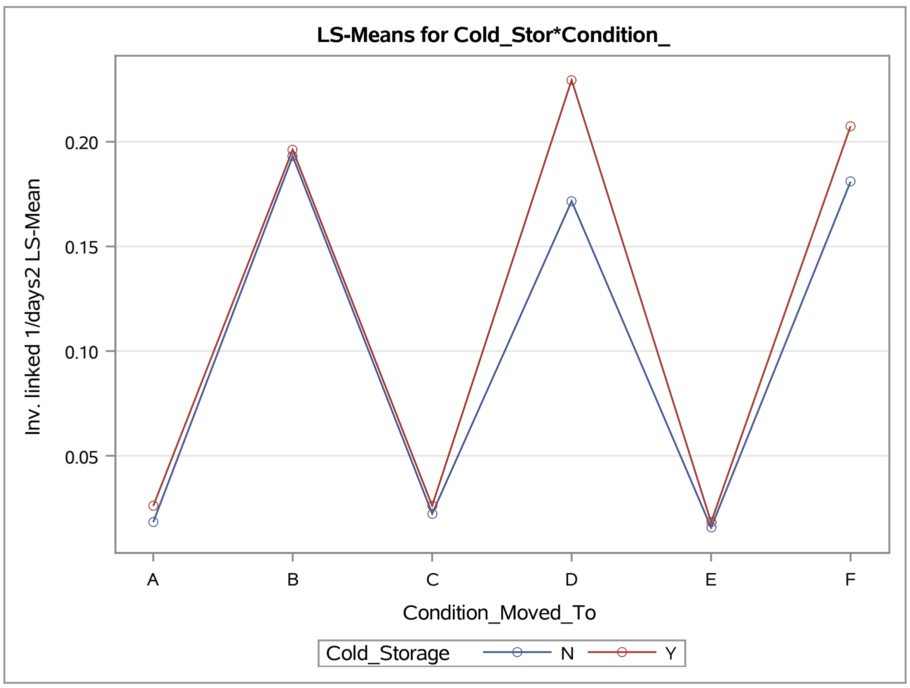
Cold_Stor*Condition_ Least Squares Means								
Cold Storage	Condition Moved To	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
N	A	-4.0029	0.1077	154	-37.16	<.0001	0.01826	0.001967
N	B	-1.6448	0.06429	154	-25.58	<.0001	0.1931	0.01241
N	C	-3.8025	0.08315	154	-45.73	<.0001	0.02231	0.001855
N	D	-1.7622	0.06753	154	-26.09	<.0001	0.1717	0.01159
N	E	-4.1555	0.2257	154	-18.41	<.0001	0.01568	0.003539
N	F	-1.7093	0.06589	154	-25.94	<.0001	0.1810	0.01193
Y	A	-3.6497	0.1845	154	-19.78	<.0001	0.02600	0.004798

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days2 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Cold_Stor*Condition_ Least Squares Means								
Cold Storage	Condition Moved To	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
Y	B	-1.6283	0.1228	154	-13.26	<.0001	0.1963	0.02411
Y	C	-3.6420	0.1524	154	-23.90	<.0001	0.02620	0.003992
Y	D	-1.4720	0.1215	154	-12.11	<.0001	0.2295	0.02789
Y	E	-4.0019	0.5797	154	-6.90	<.0001	0.01828	0.01060
Y	F	-1.5729	0.1165	154	-13.50	<.0001	0.2074	0.02416



Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

The GLIMMIX Procedure

T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)				
LS-means with the same letter are not significantly different.				
Cold Storage	Condition Moved To	Estimate		
Y	D	-1.4720		A
				A
Y	F	-1.5729	B	A
			B	A
Y	B	-1.6283	B	A
			B	A
N	B	-1.6448	B	A
			B	A
N	F	-1.7093	B	A
			B	
N	D	-1.7622	B	
Y	C	-3.6420		C
				C
Y	A	-3.6497		C
				C
N	C	-3.8025		C
				C
Y	E	-4.0019		C
				C
N	A	-4.0029		C
				C
N	E	-4.1555		C

1/days2 - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Simple Effect Comparisons of Cold_Stor*Condition_ Least Squares Means By Condition_Moved_To
Adjustment for Multiple Comparisons: Tukey-Kramer

Simple Effect Level	Cold Storage	Cold Storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Condition_Moved_To A	N	Y	-0.3532	0.2137	154	-1.65	0.1004	0.1004
Condition_Moved_To B	N	Y	-0.01643	0.1386	154	-0.12	0.9058	0.9058
Condition_Moved_To C	N	Y	-0.1606	0.1736	154	-0.93	0.3564	0.3564
Condition_Moved_To D	N	Y	-0.2902	0.1390	154	-2.09	0.0386	0.0386
Condition_Moved_To E	N	Y	-0.1536	0.6221	154	-0.25	0.8053	0.8053
Condition_Moved_To F	N	Y	-0.1364	0.1338	154	-1.02	0.3098	0.3098

1/days total - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP2
Response Variable	__days_total
Response Distribution	Exponential
Link Function	Log
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Residual PL
Degrees of Freedom Method	Containment

Class Level Information		
Class	**Levels**	**Values**
Cold_Storage	2	N Y
Experiment_Rep_	5	1 2 3 4 5
Maternal_Source	32	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Condition_Moved_To	6	A B C D E F

Number of Observations Read	537
Number of Observations Used	301

Dimensions	
G-side Cov. Parameters	2
R-side Cov. Parameters	2
Columns in X	21
Columns in Z	37
Subjects (Blocks in V)	1
Max Obs per Subject	301

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	4
Lower Boundaries	4
Upper Boundaries	0

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days total - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Optimization Information	
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	**Restarts**	**Subiterations**	**Objective Function**	**Change**	**Max Gradient**
0	**0**	**15**	-881.3752617	1.20251683	0.193609
1	**0**	**14**	-482.5830962	1.22360690	0.000219
2	**0**	**12**	-238.1030274	1.09921030	0.031824
3	**0**	**12**	-128.5432287	2.00000000	0.012432
4	**0**	**9**	-95.05222356	0.56470042	0.00628
5	**0**	**6**	-91.78362096	0.01745324	0.00016
6	**0**	**6**	-91.62796773	0.00235457	1.829E-6
7	**0**	**5**	-91.60934099	0.00071628	0.00026
8	**0**	**5**	-91.60680981	0.00009022	0.000502
9	**0**	**4**	-91.60642585	0.00001568	0.000827
10	**0**	**3**	-91.60636805	0.00000206	0.00041
11	**0**	**1**	-91.60635903	0.00000114	0.000213
12	**0**	**1**	-91.60635749	0.00000008	0.000171

Convergence criterion (PCONV=1E-6) satisfied.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	-91.61
Generalized Chi-Square	289.00
Gener. Chi-Square / DF	1.00

Covariance Parameter Estimates			
Cov Parm	**Group**	**Estimate**	**Standard Error**
Experimen(Cold_Stor)		0.01684	0.01791
Exper*Matern(Cold_S)		0.02103	0.007704
Residual (VC)	Cold_Storage N	0.02727	0.005007
Residual (VC)	Cold_Storage Y	0.03328	0.003310

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days total - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

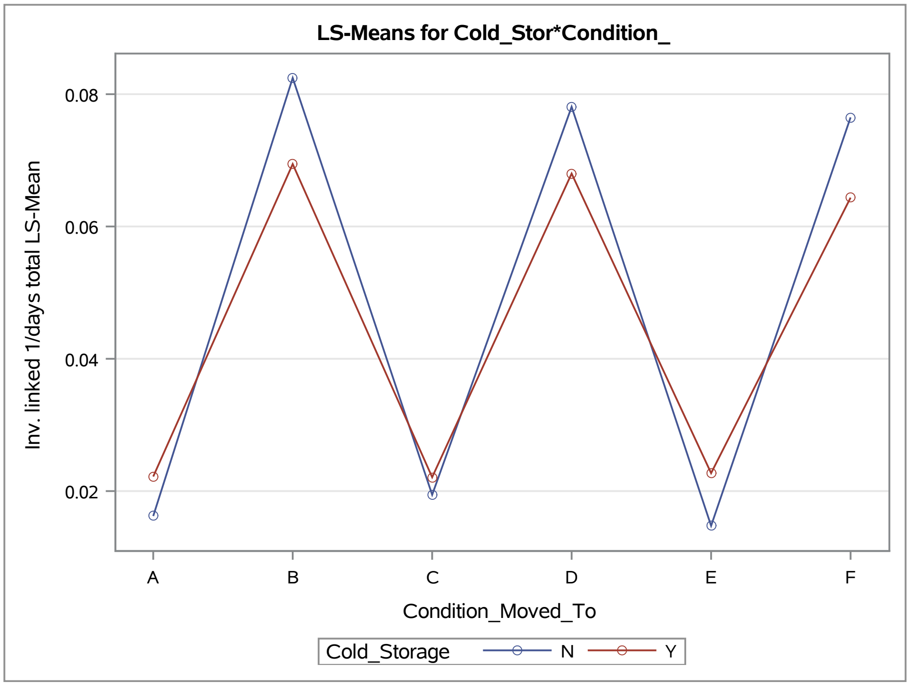
Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Cold_Storage	1	3	0.22	0.6707
Condition_Moved_To	5	260	373.30	<.0001
Cold_Stor*Condition_	5	260	8.54	<.0001

Cold_Stor*Condition_ Least Squares Means								
Cold Storage	Condition Moved To	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
N	A	-4.1210	0.1278	260	-32.24	<.0001	0.01623	0.002074
N	B	-2.4955	0.1080	260	-23.10	<.0001	0.08246	0.008908
N	C	-3.9402	0.1155	260	-34.11	<.0001	0.01944	0.002246
N	D	-2.5499	0.1095	260	-23.29	<.0001	0.07809	0.008551
N	E	-4.2161	0.2008	260	-21.00	<.0001	0.01476	0.002963
N	F	-2.5706	0.1090	260	-23.59	<.0001	0.07649	0.008335
Y	A	-3.8077	0.09451	260	-40.29	<.0001	0.02220	0.002098
Y	B	-2.6673	0.08832	260	-30.20	<.0001	0.06944	0.006133
Y	C	-3.8124	0.09054	260	-42.11	<.0001	0.02210	0.002001
Y	D	-2.6883	0.08765	260	-30.67	<.0001	0.06800	0.005960
Y	E	-3.7849	0.1273	260	-29.74	<.0001	0.02271	0.002891
Y	F	-2.7433	0.08802	260	-31.17	<.0001	0.06436	0.005665

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days total - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure



Conservative T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)

LS-means with the same letter are not significantly different.

Cold Storage	Condition Moved To	Estimate	
N	B	-2.4955	A
			A
N	D	-2.5499	A
			A
N	F	-2.5706	A

The LINES display does not reflect all significant comparisons. The following additional pairs are significantly different: (Y B,Y F), (Y A,N A), (Y C,N A).

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days total - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Conservative T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Cold Storage	Condition Moved To	Estimate	
			A
Y	B	-2.6673	A
			A
Y	D	-2.6883	A
			A
Y	F	-2.7433	A
Y	E	-3.7849	B
			B
Y	A	-3.8077	B
			B
Y	C	-3.8124	B
			B
N	C	-3.9402	B
			B
N	A	-4.1210	B
			B
N	E	-4.2161	B
The LINES display does not reflect all significant comparisons. The following additional pairs are significantly different: (Y B,Y F), (Y A,N A), (Y C,N A).			

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

1/days total - Analysis Variable
Test for the effects of cold storage on all rates
Data were not normally distributed

The GLIMMIX Procedure

Simple Effect Comparisons of Cold_Stor*Condition_ Least Squares Means By Condition_Moved_To
Adjustment for Multiple Comparisons: Tukey-Kramer

Simple Effect Level	Cold Storage	Cold Storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Condition_Moved_To A	N	Y	-0.3133	0.1590	260	-1.97	0.0498	0.0498
Condition_Moved_To B	N	Y	0.1718	0.1395	260	1.23	0.2193	0.2193
Condition_Moved_To C	N	Y	-0.1278	0.1468	260	-0.87	0.3846	0.3846
Condition_Moved_To D	N	Y	0.1384	0.1403	260	0.99	0.3246	0.3246
Condition_Moved_To E	N	Y	-0.4312	0.2377	260	-1.81	0.0709	0.0709
Condition_Moved_To F	N	Y	0.1727	0.1401	260	1.23	0.2186	0.2186

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Count/Maternal Source for Days1 -- Apparent Parasitism

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP2OUT
Response Variable	days1count
Response Distribution	Poisson
Link Function	Log
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Residual PL
Degrees of Freedom Method	Containment

Class Level Information		
Class	**Levels**	**Values**
Cold_Storage	2	N Y
Experiment_Rep_	5	1 2 3 4 5
Maternal_Source	32	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Condition_Moved_To	6	A B C D E F

Number of Observations Read	149
Number of Observations Used	149

Dimensions	
G-side Cov. Parameters	1
Columns in X	21
Columns in Z	5
Subjects (Blocks in V)	1
Max Obs per Subject	149

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	1
Lower Boundaries	1
Upper Boundaries	0
Fixed Effects	Profiled
Starting From	Data

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Count/Maternal Source for Days1 -- Apparent Parasitism

The GLIMMIX Procedure

Iteration History					
Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
0	0	5	346.61893557	1.66951659	4.078E-6
1	0	3	407.68211729	1.93004002	0.000046
2	0	5	446.090333	2.00000000	4.312E-8
3	0	2	474.91167847	1.99424001	0.000012
4	0	3	491.5135885	1.99891439	1.413E-7
5	0	2	496.71210788	0.02186457	3.122E-7
6	0	1	497.34260707	0.00125952	1.753E-7
7	0	1	497.37937091	0.00006465	2.859E-9
8	0	0	497.38125974	0.00000000	6.914E-7

Convergence criterion (PCONV=1.11022E-8) satisfied.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	497.38
Generalized Chi-Square	91.42
Gener. Chi-Square / DF	0.67

Covariance Parameter Estimates		
Cov Parm	Estimate	Standard Error
Experimen(Cold_Stor)	7.7896	7.5162

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Cold_Storage	1	3	0.37	0.5868
Condition_Moved_To	5	134	0.54	0.7431
Cold_Stor*Condition_	5	134	0.25	0.9373

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Count/Maternal Source for Days1 -- Apparent Parasitism

The GLIMMIX Procedure

Condition_Moved_To Least Squares Means							
Condition Moved To	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Mean**	**Standard Error Mean**
A	0.1879	1.3001	134	0.14	0.8853	1.2067	1.5688
B	0.08616	1.3002	134	0.07	0.9473	1.0900	1.4172
C	-0.1066	1.3006	134	-0.08	0.9348	0.8989	1.1691
D	-0.00197	1.3003	134	-0.00	0.9988	0.9980	1.2978
E	-0.01600	1.3003	134	-0.01	0.9902	0.9841	1.2796
F	0.09268	1.3005	134	0.07	0.9433	1.0971	1.4268

Differences of Condition_Moved_To Least Squares Means Adjustment for Multiple Comparisons: Tukey-Kramer							
Condition Moved To	**Condition Moved To**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Adj P**
A	B	0.1017	0.1954	134	0.52	0.6034	0.9953
A	C	0.2945	0.1977	134	1.49	0.1386	0.6713
A	D	0.1899	0.1967	134	0.97	0.3360	0.9280
A	E	0.2039	0.1968	134	1.04	0.3020	0.9049
A	F	0.09523	0.1980	134	0.48	0.6313	0.9968
B	C	0.1928	0.1984	134	0.97	0.3330	0.9262
B	D	0.08813	0.1973	134	0.45	0.6558	0.9977
B	E	0.1022	0.1973	134	0.52	0.6055	0.9954
B	F	-0.00651	0.1986	134	-0.03	0.9739	1.0000
C	D	-0.1046	0.1996	134	-0.52	0.6010	0.9951
C	E	-0.09060	0.1997	134	-0.45	0.6508	0.9975
C	F	-0.1993	0.2009	134	-0.99	0.3231	0.9199
D	E	0.01403	0.1985	134	0.07	0.9438	1.0000
D	F	-0.09465	0.1998	134	-0.47	0.6366	0.9970
E	F	-0.1087	0.1999	134	-0.54	0.5876	0.9942

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Count/Maternal Source for Days1 -- Apparent Parasitism

The GLIMMIX Procedure

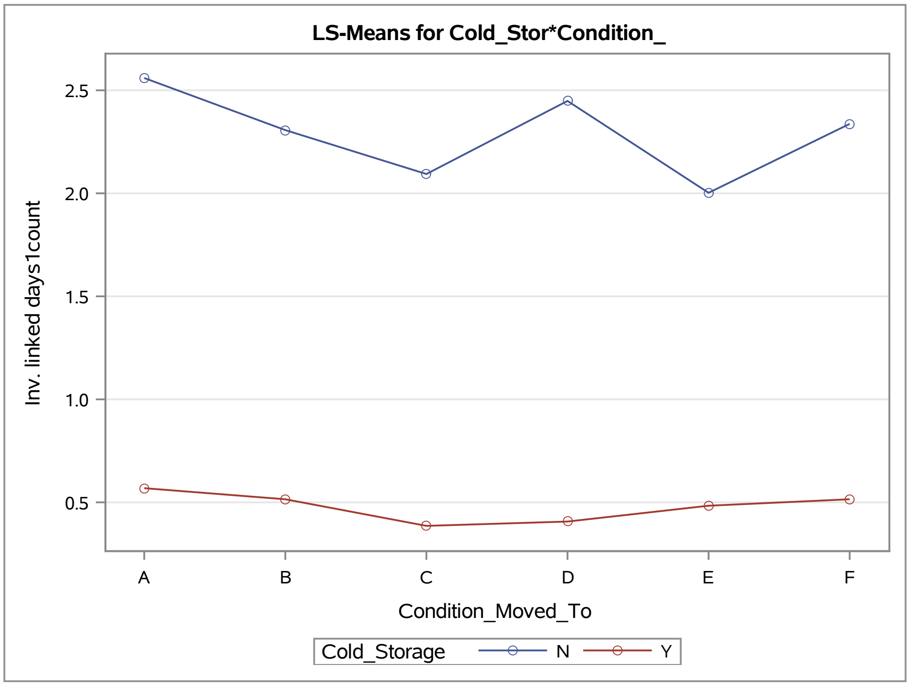
Tukey-Kramer Grouping for Condition_Moved_To Least Squares Means (Alpha=0.05)		
LS-means with the same letter are not significantly different.		
Condition Moved To	Estimate	
A	0.1879	A
		A
F	0.09268	A
		A
B	0.08616	A
		A
D	-0.00197	A
		A
E	-0.01600	A
		A
C	-0.1066	A

Cold_Stor*Condition_ Least Squares Means								
Cold Storage	Condition Moved To	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
N	A	0.9399	1.9845	134	0.47	0.6366	2.5596	5.0796
N	B	0.8359	1.9846	134	0.42	0.6743	2.3068	4.5780
N	C	0.7389	1.9845	134	0.37	0.7102	2.0936	4.1547
N	D	0.8954	1.9850	134	0.45	0.6527	2.4483	4.8600
N	E	0.6944	1.9850	134	0.35	0.7270	2.0025	3.9751
N	F	0.8489	1.9856	134	0.43	0.6697	2.3370	4.6403
Y	A	-0.5640	1.6800	134	-0.34	0.7376	0.5689	0.9558
Y	B	-0.6635	1.6802	134	-0.39	0.6935	0.5150	0.8654
Y	C	-0.9521	1.6815	134	-0.57	0.5722	0.3859	0.6490
Y	D	-0.8993	1.6803	134	-0.54	0.5934	0.4068	0.6836
Y	E	-0.7264	1.6801	134	-0.43	0.6662	0.4836	0.8126
Y	F	-0.6635	1.6802	134	-0.39	0.6935	0.5150	0.8654

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Count/Maternal Source for Days1 -- Apparent Parasitism

The GLIMMIX Procedure



T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Cold Storage	Condition Moved To	Estimate	
N	A	0.9399	A
			A
N	D	0.8954	A
			A
N	F	0.8489	A
			A
N	B	0.8359	A
			A
N	C	0.7389	A
			A

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Experiment 2

Count/Maternal Source for Days1 -- Apparent Parasitism

The GLIMMIX Procedure

T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Cold Storage	Condition Moved To	Estimate	
N	E	0.6944	A
			A
Y	A	-0.5640	A
			A
Y	F	-0.6635	A
			A
Y	B	-0.6635	A
			A
Y	E	-0.7264	A
			A
Y	D	-0.8993	A
			A
Y	C	-0.9521	A

Simple Effect Comparisons of Cold_Stor*Condition_ Least Squares Means By Condition_Moved_To Adjustment for Multiple Comparisons: Tukey-Kramer								
Simple Effect Level	Cold Storage	Cold Storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Condition_Moved_To A	N	Y	1.5039	2.6001	134	0.58	0.5640	0.5640
Condition_Moved_To B	N	Y	1.4994	2.6003	134	0.58	0.5652	0.5652
Condition_Moved_To C	N	Y	1.6909	2.6011	134	0.65	0.5168	0.5168
Condition_Moved_To D	N	Y	1.7947	2.6007	134	0.69	0.4913	0.4913
Condition_Moved_To E	N	Y	1.4208	2.6006	134	0.55	0.5857	0.5857
Condition_Moved_To F	N	Y	1.5124	2.6011	134	0.58	0.5619	0.5619

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Experiment 2

Count/Maternal Source for DaysTotal -- Actual Parasitism

The GLIMMIX Procedure

Model Information	
Data Set	WORK.EXP2OUT
Response Variable	daystotalcount
Response Distribution	Poisson
Link Function	Log
Variance Function	Default
Variance Matrix	Not blocked
Estimation Technique	Residual PL
Degrees of Freedom Method	Containment

Class Level Information		
Class	**Levels**	**Values**
Cold_Storage	2	N Y
Experiment_Rep_	5	1 2 3 4 5
Maternal_Source	32	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Condition_Moved_To	6	A B C D E F

Number of Observations Read	149
Number of Observations Used	149

Dimensions	
G-side Cov. Parameters	1
Columns in X	21
Columns in Z	5
Subjects (Blocks in V)	1
Max Obs per Subject	149

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	1
Lower Boundaries	1
Upper Boundaries	0
Fixed Effects	Profiled
Starting From	Data

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Experiment 2

Count/Maternal Source for DaysTotal -- Actual Parasitism

The GLIMMIX Procedure

Iteration History					
Iteration	**Restarts**	**Subiterations**	**Objective Function**	**Change**	**Max Gradient**
0	**0**	**4**	343.04983757	2.00000000	0.000051
1	**0**	**2**	407.9518879	0.58966149	0.000179
2	**0**	**2**	424.33294025	0.14246435	3.172E-8
3	**0**	**1**	426.32427611	0.00641497	8.751E-8
4	**0**	**1**	426.39108759	0.00001090	2.2E-8
5	**0**	**0**	426.39119605	0.00000000	7.248E-8

Convergence criterion (PCONV=1.11022E-8) satisfied.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	426.39
Generalized Chi-Square	171.42
Gener. Chi-Square / DF	1.25

Covariance Parameter Estimates		
Cov Parm	**Estimate**	**Standard Error**
Experimen(Cold_Stor)	0.2713	0.2497

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Cold_Storage	1	3	1.34	0.3314
Condition_Moved_To	5	134	10.86	<.0001
Cold_Stor*Condition_	5	134	0.18	0.9710

Condition_Moved_To Least Squares Means							
Condition Moved To	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Mean**	**Standard Error Mean**
A	-0.1969	0.3456	134	-0.57	0.5699	0.8213	0.2838
B	0.9669	0.2718	134	3.56	0.0005	2.6298	0.7148
C	0.2012	0.3003	134	0.67	0.5040	1.2229	0.3672
D	0.8705	0.2748	134	3.17	0.0019	2.3880	0.6563

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Experiment 2

Count/Maternal Source for DaysTotal -- Actual Parasitism

The GLIMMIX Procedure

Condition_Moved_To Least Squares Means							
Condition Moved To	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
E	-1.9254	0.6080	134	-3.17	0.0019	0.1458	0.08866
F	1.0158	0.2724	134	3.73	0.0003	2.7616	0.7522

Differences of Condition_Moved_To Least Squares Means Adjustment for Multiple Comparisons: Tukey-Kramer							
Condition Moved To	Condition Moved To	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
A	B	-1.1638	0.2800	134	-4.16	<.0001	0.0008
A	C	-0.3981	0.3078	134	-1.29	0.1981	0.7882
A	D	-1.0673	0.2832	134	-3.77	0.0002	0.0033
A	E	1.7285	0.6119	134	2.82	0.0055	0.0597
A	F	-1.2127	0.2807	134	-4.32	<.0001	0.0004
B	C	0.7657	0.2220	134	3.45	0.0008	0.0096
B	D	0.09643	0.1864	134	0.52	0.6058	0.9954
B	E	2.8923	0.5736	134	5.04	<.0001	<.0001
B	F	-0.04890	0.1826	134	-0.27	0.7893	0.9998
C	D	-0.6693	0.2260	134	-2.96	0.0036	0.0414
C	E	2.1266	0.5877	134	3.62	0.0004	0.0055
C	F	-0.8146	0.2229	134	-3.65	0.0004	0.0049
D	E	2.7958	0.5751	134	4.86	<.0001	<.0001
D	F	-0.1453	0.1875	134	-0.77	0.4397	0.9713
E	F	-2.9412	0.5739	134	-5.12	<.0001	<.0001

Tukey-Kramer Grouping for Condition_Moved_To Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Condition Moved To	Estimate		
F	1.0158		A
			A
B	0.9669		A
			A

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

Count/Maternal Source for DaysTotal -- Actual Parasitism

The GLIMMIX Procedure

Tukey-Kramer Grouping for Condition_Moved_To Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Condition Moved To	Estimate		
D	0.8705		A
C	0.2012		B
			B
A	-0.1969	C	B
		C	
E	-1.9254	C	

Cold_Stor*Condition_ Least Squares Means								
Cold Storage	Condition Moved To	Estimate	Standard Error	DF	t Value	Pr > |t|	Mean	Standard Error Mean
N	A	-0.5967	0.5797	134	-1.03	0.3052	0.5506	0.3192
N	B	0.7275	0.4291	134	1.70	0.0923	2.0700	0.8882
N	C	-0.1029	0.4857	134	-0.21	0.8325	0.9022	0.4382
N	D	0.6843	0.4377	134	1.56	0.1203	1.9823	0.8677
N	E	-2.4055	1.0658	134	-2.26	0.0256	0.09022	0.09616
N	F	0.7896	0.4313	134	1.83	0.0694	2.2026	0.9500
Y	A	0.2030	0.3765	134	0.54	0.5907	1.2250	0.4612
Y	B	1.2063	0.3338	134	3.61	0.0004	3.3409	1.1151
Y	C	0.5054	0.3532	134	1.43	0.1548	1.6576	0.5855
Y	D	1.0567	0.3324	134	3.18	0.0018	2.8768	0.9564
Y	E	-1.4452	0.5853	134	-2.47	0.0148	0.2357	0.1380
Y	F	1.2420	0.3328	134	3.73	0.0003	3.4624	1.1523

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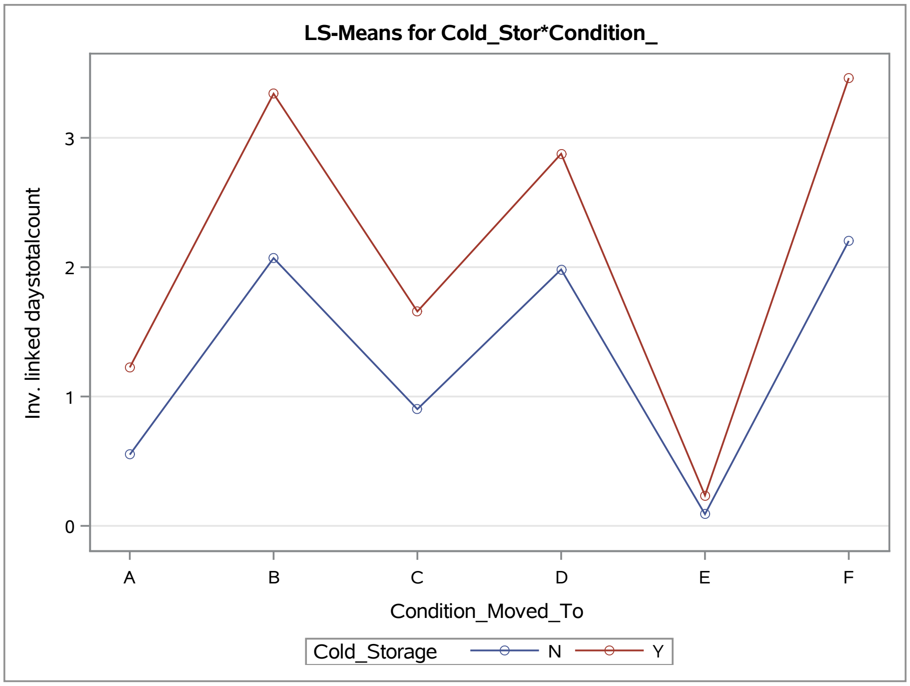
Experiment 2

Count/Maternal Source for DaysTotal -- Actual Parasitism

The GLIMMIX Procedure



Conservative T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)

LS-means with the same letter are not significantly different.

Cold Storage	Condition Moved To	Estimate			
Y	F	1.2420		A	
				A	
Y	B	1.2063		A	
				A	
Y	D	1.0567	B	A	
			B	A	

The LINES display does not reflect all significant comparisons. The following additional pairs are significantly different: (Y D,Y C), (Y D,Y A), (N F,N C), (N B,N C), (N D,N C).

Client: Nina Rudin & Kris Giles ENTO
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Experiment 2

Count/Maternal Source for DaysTotal -- Actual Parasitism

The GLIMMIX Procedure

Conservative T Grouping for Cold_Stor*Condition_ Least Squares Means (Alpha=0.05)					
LS-means with the same letter are not significantly different.					
Cold Storage	Condition Moved To	Estimate			
N	F	0.7896	B	A	
			B	A	
N	B	0.7275	B	A	
			B	A	
N	D	0.6843	B	A	
			B		
Y	C	0.5054	B	C	
			B	C	
Y	A	0.2030	B	C	
			B	C	
N	C	-0.1029	B	C	D
				C	D
N	A	-0.5967	E	C	D
			E		D
Y	E	-1.4452	E		D
			E		
N	E	-2.4055	E		
The LINES display does not reflect all significant comparisons. The following additional pairs are significantly different: (Y D,Y C), (Y D,Y A), (N F,N C), (N B,N C), (N D,N C).					

Simple Effect Comparisons of Cold_Stor*Condition_ Least Squares Means By Condition_Moved_To Adjustment for Multiple Comparisons: Tukey-Kramer								
Simple Effect Level	Cold Storage	Cold Storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Condition_Moved_To A	N	Y	-0.7996	0.6912	134	-1.16	0.2494	0.2494
Condition_Moved_To B	N	Y	-0.4787	0.5436	134	-0.88	0.3801	0.3801
Condition_Moved_To C	N	Y	-0.6083	0.6006	134	-1.01	0.3130	0.3130
Condition_Moved_To D	N	Y	-0.3724	0.5496	134	-0.68	0.4992	0.4992

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Experiment 2

Count/Maternal Source for DaysTotal -- Actual Parasitism

The GLIMMIX Procedure

Simple Effect Comparisons of Cold_Stor*Condition_ Least Squares Means By Condition_Moved_To
Adjustment for Multiple Comparisons: Tukey-Kramer

Simple Effect Level	Cold Storage	Cold Storage	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Condition_Moved_To E	N	Y	-0.9603	1.2160	134	-0.79	0.4311	0.4311
Condition_Moved_To F	N	Y	-0.4523	0.5448	134	-0.83	0.4078	0.4078

Client: Nina Rudin & Kris Giles ENTO
Program: \Rudin, Nina\An Analysis.sas
Experiment 2

VITA

Nina Rudin

Candidate for the Degree of

Master of Science

Thesis: EFFECTS OF TEMPERATURE AND LIGHT CYCLE ON THE DEVELOPMENT OF *APHELINUS NIGRITUS* (HOWARD) IN THE SOUTHERN GREAT PLAINS

Major Field: Entomology and Plant Pathology

Biographical:

Education:

Completed the requirements for the Master of Science in Entomology and Plant Pathology at Oklahoma State University, Stillwater, Oklahoma in December 2022.

Completed the requirements for the Bachelor of Science in Biology at Oregon State University, Corvallis, Oregon in 2019.

Experience:

Student Laboratory Technician, Invertebrate Pest Lab, Oregon State University, September 2017- December 2019

Student Laboratory Technician, Jenkins Lab, Oregon State University, September 2018- December 2019

Student Laboratory Technician, Hooven Lab, Oregon State University, June 2018- December 2019

Professional Memberships:

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