**What do I propose to do?** In May 2012, my home institution, The University of Tennessee, signed a Memorandum of Understanding with the Croatian Agro-business, Agrokor, and University of J.J. Strossmayer University in Osijek. This agreement led me and several other faculty visiting nine dairy farms and associated heifer and calf facilities from Belje d. d. (a company within Agrokor) to evaluate their production practices and make practical recommendations. One aspect of management that was critically lacking was a focus on cow comfort, or welfare. Based on the preliminary assessment that I have conducted with these Croatian farms, my overall objective is to implement a welfare assessment program for dairy cattle during the five months that I was invited to stay in Croatia. To address this overall objective, I propose the following specific research objectives:

**My primary objective will be to assess the current welfare status of dairy cows across a variety of management systems on dairy farms in Croatia.** To conduct this objective, I will use the systems established by Gibbons et al. (2012), that detailed a highly repeatable program for the assessment of welfare, and Rushen et al. (2012), that detailed automated methods for assessing welfare. I will conduct a detailed welfare assessment of each farm within 2 weeks of my arrival in Croatia and then each farm will be re-assessed on a monthly basis.

**My secondary objective will be to determine the behavioral consistency and the effect of management on cow traffic of dairy cows milked within an automatic milking system.** Initially, we will focus on determining the consistency of behavior within this system. Once I have identified a subgroup of cows that do not use the system correctly, we will evaluate the effects of management of the holding area on their welfare. These objectives will be completed in close collaboration with faculty and students from University of J.J. Strossmayer University in Osijek and staff from Belje d. d. which will involve direct involvement on the research projects, lectures at the University on topics related to these objectives, and opportunities for field trips to the farms for hands-on experience with welfare assessment for students at University of J.J. Strossmayer University in Osijek.

**What is the academic and professional context of the project?**

**Why is it important to assess welfare?**

While no universally accepted definition of animal welfare exists for farm animals, the one that may offer the most practical basis was put forward by Fraser et al. (1997). Within this definition, welfare of dairy cows can be broken down into the three questions that welfare concerns focus on: 1) what is her biological function (this would include factors such as milk yield, milk quality, reproductive success, etc.), 2) what is her affective state (this generally is measured by the presence or absence of a stress response), and 3) is she behaving naturally (for dairy cows in a production system, this would usually focus on her daily time budget). These questions were often affected by the same management practice. For example, overstocking, or housing more cows than the available resting or feeding resources in a pen can support (Krawczel et al., 2012a) can reduce welfare from all three of these perspectives. Bach et al. (2008) detailed the positive relationship between freestall availability and milk yield. Furthermore, when stall maintenance (defined as poor, moderate, or well maintained) was included in the model, approximately 40% of the overall variation in milk yield across these farms was explained (Bach et al., 2008). Cows responded with an increased cortisol response (a commonly measured stress hormone; Munksgaard and Simonsen, 1996) to being deprived of the ability to lie down. This was the most commonly observed effect of overstocking on the behavior of dairy cows (Fregonesi et al., 2007; Krawczel et al., 2012a; Krawczel et al., 2012b). While this
example illustrated a management practice that affected all aspects of welfare, a deficiency in any aspect was sufficient to conclude that welfare was detrimentally affected using the definition of Fraser et al. (1997).  

**Measuring animal welfare**  
Animal welfare can be measured by animal or facilities-based measurements. Animal-based measurements include hygiene scoring, hock and knee injury scoring, and locomotion scores. These measurements are informative as they can provide information related to the level of risk for disease (hygiene; Schreinder and Ruegg, 2003), the suitability of the management of the facility (injuries to knees or hocks; Norring et al., 2008), or suitability of the facility overall (lameness; Flower and Weary, 2006). Facilities-based assessments rely on the direct evaluation of the physical environment to predict its suitability for the cows. Aspects of design, including bedding amount, bedding quality, freestall width, and neck rail height and location, have affected aspects of welfare in designed research trials (Tucker et al., 2009; Fregonesi et al., 2007; Tucker et al., 2003; Bernardi et al., 2009).

![Photo 1](image-url)  
*Photo 1: Illustration of cow comfort issues stemming from poor manure management and overcrowding of the housing environment. Cow hygiene issues will likely cause subsequent health problems.*

**Automated assessment of welfare**  
Measuring lying behavior as a means to automate welfare assessment is promising. Cows place the greatest priority on resting time when access to resources was limited in an attempt to maintain overall resting time (Munksgaard et al., 2005). Cows spend the greatest portion of their day engaged in rest; in general, cows will spend 10 to 14 hours per day resting, 3 to 5 hours per day feeding, 2 to 3 hours per day in other activities (standing, walking, grooming, etc.), and approximately 30 minutes per day drinking (Grant, 2008). In addition to being the largest portion of their day, lying is the behavior with the least amount of flexibility. Reduced access to feed resulted in increased feeding rates (Proudfoot et al., 2009) while a brief period of lost lying time...
affected behavior for several subsequent days (Cooper et al., 2007). There are multiple validated means for the automated measuring of lying behavior (Ledgerwood et al., 2010; Neilsen et al., 2010; O’Driscoll et al., 2008).

Photo 2: Freestall designs and management can alter lying times and general use

Effects of automatic milking systems

In addition to measuring lying behavior, automatic milk systems represent a technology that may assist with the long-term evaluation of welfare on commercial farms. However, as they are still a relatively new technology (the first were installed in the Netherlands in 1992 and 8,000 were installed worldwide as of 2009 (de Koning, 2010)), there remain challenges for their implementation on commercial farms. Large variations in the interval between the times that cows were milked resulted in lower milk production, especially from mature cows (Bach and Busto, 2005), but the primary causes of variation are unknown (Jacobs and Siegford, 2012). The farms in Croatia utilize the forced traffic pattern (cows must pass through the milking system to gain access to feed), the merits of which were debated in the literature (reviewed by Jacobs and Siegford, 2012). This approach requires a large holding area in front of the entry for the milking unit and leads to cows unable to access resources for an extended period, causing a response similar to overcrowding.
Why does it need to be done? What significance does it hold for your discipline, your development, the host country’s benefit? The main significance for my discipline from the work that I am proposing is that it will be the first data on the state of dairy cow welfare from Eastern Europe in a climate similar to Tennessee. For my development, I will be building upon relationships that I have established in Croatia and have the chance to develop a welfare assessment program that could be implemented on dairy farms in Tennessee. I will also have an opportunity to work with automatic milking systems. There are a very limited number of research facilities in the US with this technology, and none in the Southeast, but it might represent an important technology suitable for dairy farming. For my host, my proposed project introduces them to an aspect of management that they are lacking, cow comfort.

How will you carry out the proposed research? For the primary objective, I will conduct my assessment of the dairy farms within the Agrokor system (Topolik, Čeminac, Popovac, Zeleno Polje, Mitrovac, Prosine, Klisa, Dubrava and Jakobovac) during the first two weeks following my arrival in Croatia. After the initial assessment, subsequent evaluations will be completed on a monthly basis (for the five-month duration of my stay) over the course of 7 to 10 days each month and each farm manager will record any management changes or deviations within a project log book that will remain at each facility. The assessment will be conducted following the protocols developed by Gibbons et al. (2012) as their assessment program was developed to provide repeatable measure on commercial farms.

In general we will evaluate the following animal measures from 30 focal cows on each farm:

- **Claw length** – this provides an assessment of the extent that cows receive routine hoof care and extent that cows are at risk for lameness. Overgrowth will be quantified as present or absent. A claw that rests on the ground at less than a 45° will be considered overgrown.
- **Body condition score** – this provides an assessment of the state of the nutrition program and follows the guidelines set forth by Wildman et al. (1982). Body condition will be assessed using a 1-to-5 scale where 1 is emaciated and a 5 is obese (Wildman et al., 1982).

- **Hock and knee injuries** – this provides an assessment of the suitability and management of the freestalls, or other resting space provided within the housing facility, and stall surface. Hocks will be scored using a 0-to-3 scale where 0 reflects a hock with no visible swelling or hair loss and a 3 reflects a hock with major swelling and may have an area of more than 2.5 cm of hair loss. Knee injuries will be assessed using the same scale where 0 equals a knee that is free of swelling or hair loss and a 3 equals a knee with major swelling (greater than 2.5 cm).

- **Cow hygiene** – this assessment was previously associated with the risk for intra-mammary infection (Schreinder and Ruegg, 2003). The legs, flanks, and udders of enrolled cows will be scored on a 1-to-4 scale where 1 equals an area that is relatively free of manure or other soiling and a 4 equals an area that heavily contaminated with dry manure or other soiling.

- **Locomotion score** – due to the poor repeatability of many gait scoring systems (Gibbons et al., 2012), live gait scoring will focus on the presence or absence of a visible limp. Cows free from a visible limp will be scored as sound and cows with a visible limp will be scored as lame. A score will be assigned after a cow has taken 4 complete strides.

- **Behavior assessment** – HOBO dataloggers (Onset, Inc. Bourne, MA) will be used to determine the lying behavior of focal cows at each farm to determine the effects of facilities and management on cow comfort. On the first visit, a datalogger will be affixed to the rear leg of the focal cows along the metatarsal bones. It will be removed 3 days later during a subsequent visit and the data will be summarized as the daily lying time (h/d), daily number of lying bouts (n/d), and lying bout duration (min/bout).

We will also evaluate the following aspects of the primary housing facility of these farms:

- **Stall bedding wetness** – this is a factor of management that can affect stall usage (Fregonesi et al., 2007) and milk production (Bach et al., 2008). It will be assessed using a “kneel-down test” to determine the extent that moisture moves through a folded paper towel (Gibbons et al., 2012).

- **Alley cleanliness** – the cleanliness of the alleys will be assessed approximately 20 min prior to scraping or flushing and again approximately 20 min after scraping or flushing. Alleys will be scored on a 0-to-3 scale with a floor covered in 0.5 cm or less of manure to be clean (score = 0) and a floor covered in more than 3 cm of manure as very dirty (score = 3). Alley cleanliness will also be assessed from the number of cows observed slipping or falling. Cows will be observed moving into the parlor for milking. This will be assigned a numeric score from 0-to-3 where 0 equals no cows slipping and a 3 equals 2% of cows falling or 15% or more slipping.

- **General housing characteristics** – the total number of cows, usable stalls, total dimensions of the pen, total number of usable feeding spaces, stall base, flooring type, water space, and availability of foot bath will be recorded. Stall dimensions will be further assessed from length, width, bed length, brisket board height, lunge space, neck rail height, and curb height.

For the secondary objective, we will use the following approach (this objective will be staged in between the monthly data collection related to the welfare assessment):

We will focus on the Topolik facility, which is the only farm that utilizing an automatic milking system for its herd. The initial phase of this study will focus on consistency. We will follow all cows within a pen for 9 days (2 days for adaptation to wearing a datalogger and 7 days for data collection).
collection) within each of the 4 main housing pens at the farm. During the 7-day collection period we will use the following response variables:

- **Behavior assessment** – conducted as described above. The data from the dataloggers will be used to determine standing/lying times, duration of lying bouts, and diurnal patterns of standing and lying

- **Milking assessment** – using the records from the milking system, the time each cow entered the system, the total milk produced, the total number of times the system was entered, and any failures to attach will be measured

- **Cows to be “fetched”** – the identification of each cow that does not voluntarily enter the milking unit within the pre-determined (by farm management) 12-hour interval and needs to be moved to the milking unit by the farm staff will be recorded

The focus of the second phase of data collection will be on the sub-group of cows “fetched” consistently by the farm staff (≥ 4 times during the consistency phase). I will implement three treatments to determine the effect of management on cow traffic through the system: 1) control – holding area stocked at the maximum number of cows that will fit, 2) holding area stocking at 75% of the maximum, and 3) holding area stocked at 50% of the maximum. These treatments will be imposed for 3 weeks at a time and rotated through until each treatment is imposed on each of the three study pens. During the third week, I will collect the following information from cows that were moved into the holding pen at this time:

- **Behavior assessment** – conducted as described above

- **Time in the holding pen** – the average time that cows spend in the holding pen will be measured from the time that the last cow is moved into the holding pen until the last cow enters the milking unit. This will be measured on three consecutive days during the third week.

- **Productivity** – using the records from the automatic milking system, average yield (kg of milk per cow per day) and milk quality (somatic cell count (cells per mL), milk fat (%), and milk protein (%)) will be measured

- **Latency to lie down** – the time from a cow exiting the milking unit until she lies down will be recorded by direct observation from a deck located above the housing pens that offers an elevated view of the dairy barn. This will be measured on three consecutive days during the third week. This was previously associated with milk quality and mastitis (DeVries et al., 2011).

**How will your results be disseminated? (publications, conference presentations, joint collaboration)?** The results of my studies will be disseminated in three ways. First, my results will be presented at University of J.J. Strossmayer University in Osijek as part of a series of lectures on the welfare and behavior of dairy cows. Once I return to the US, I plan to present my findings at the conferences of the International Society of Applied Ethology and the American Dairy Science Association. This will be followed by publication in peer-reviewed journals. Finally, my findings will be incorporated into the newsletter that I write for Tennessee dairy producers and, potentially, as an article for the popular press magazine, *Hoard’s Dairyman.*