Participation in the XV International Symposium on Chironomidae, St Paul, Minnesota, and study tour to Washington State University

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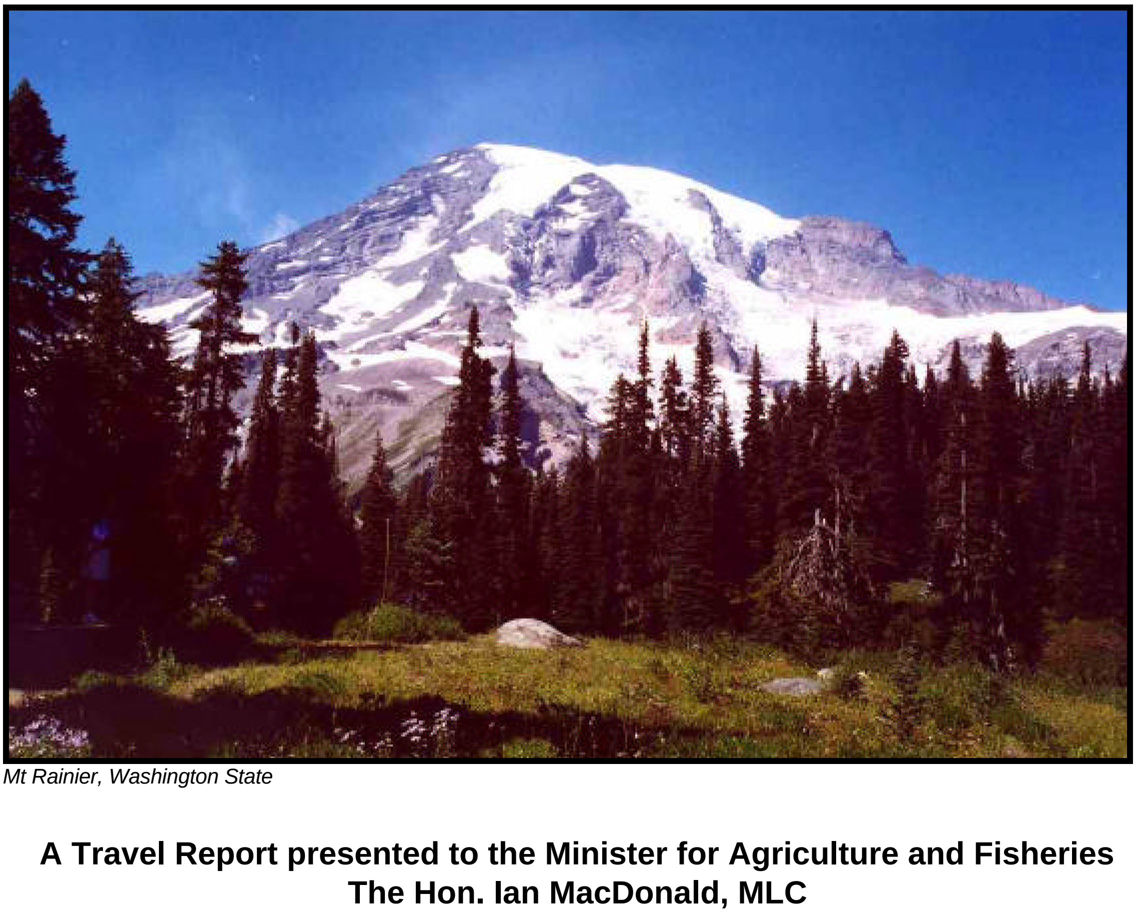

Mt Rainier, Washington State

A Travel Report presented to the Minister for Agriculture and Fisheries
The Hon. Ian MacDonald, MLC
and the
Cooperative Research Centre for Sustainable Rice Production

CONTENTS

Reasons for travel

- to participate in the XV International Symposium on the Chironomidae, where the officer will be presenting a paper (as senior author) on chironomid colonisation of rice fields, and developing new collaborative research projects with Professor Arshad Ali of the University of Florida and other chironomid researchers.

- to allow the completion of 2 collaborative research papers with Professor David James of Washington State University, and to examine the potential use of herbivore-induced plant volatiles (HIPVs) as a method for enhancing the biological control of crop pests in low-input cropping systems in southern New South Wales.

- to participate in a 2 day workshop at Washington State University examining future trends in entomological research and opportunities for the development and funding of collaborative research programs.

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SECTION 1. SUMMARY

This report summarises activities, findings and recommendations arising from overseas travel between Sunday 10 August and Monday 25 August 2003, during which time I spent approximately 5 days participating in the XV International Symposium on Chironomidae in St Paul, Minnesota, 2 days at the Washington State University Department of Entomology faculty meeting at Mt Vernon, and 7 days at the Washington State University Research Centre, Prosser.

This trip has placed me in a better position to develop and deliver research programs designed to maintain the NSW agricultural industries at the forefront of both productivity and environmental sustainability. Specific recommendations arising from the travel include:

- The development of research proposals aimed at determining the selectivity of rice bloodworm control treatments to *Chironomus tepperi*, the principal pest species attacking rice in NSW. Many of the bloodworm control treatments currently in use are likely to be killing a broad range of aquatic insects that are actually beneficial to the crop. Farmers have chosen these treatments in preference to more advanced approaches for many years, primarily due to their low cost, however in so doing they have potentially had a detrimental effect on invertebrate food chains within the rice agroecosystem. Because of the importance of aquatic food sources to terrestrial food chains, growers may obtain a greater benefit from more selective materials which, although potentially more expensive, may allow better conservation of non-target species. This will lead to higher in-crop biodiversity and ultimately greater populations of both aquatic and terrestrial predators that will provide better natural control of pests such as mosquitoes and armyworms.
- Invertebrate research programs in rice, conducted either for pest management or environmental assessment purposes, need to have a greater emphasis on community ecology and structure, rather than on just the populations of pest or indicator taxa responding to chemical applications. The multivariate analysis tools necessary or looking at community structure (multidimensional scaling, detrended correspondence analysis, etc) are now readily available in desktop statistics packages, and their use should be incorporated into all rice pest management proposals. Utilising these techniques will require additional sampling effort in field situations, and new research proposals should be prepared and resourced with these requirements in mind.
- The development of a herbivore-induced plant volatile (HIPV) research program to evaluate the usefulness of these compounds for manipulating populations of beneficial insects in NSW crops. HIPVs are released by many crop plants in response to damage by pest species, and serve to attract predators (and potentially parasitoids) into crops that are experiencing damage. Many of the most common HIPVs have been identified by plant chemists, and studies at Washington State University have shown that lures placed in orchards, vineyards and hop-yards attract additional beneficial insects into these crops, enhancing natural biocontrol and potentially reducing the need for chemical control of pest species. Whilst HIPVs could be useful in rice crops, these materials show the greatest potential in low-input horticulture and viticulture. Grapes, citrus, and stonefruit are the most likely areas for HIPV use in NSW, however they may also be of benefit in organic agriculture and vegetable production. An initial trial program has been developed for the Yanco area, and the work will be conducted in collaboration with Associate Professor David James of Washington State University.

Contacts made or renewed with other researchers at the XV International Symposium on Chironomidae (particularly Professors Arshad Ali and Xinhua Wang) are likely to lead to the development of future collaborative projects on chironomid ecology and management.

SECTION 2. ITINERARY OUTLINE

Key dates:

Sunday 10 August 2003	Arrive St Paul, Minnesota for XV International Symposium on Chironomidae, University of Minnesota
Saturday 16 August 2003	Depart St Paul, Minnesota; Arrive Washington State University, Prosser
Sunday 17 August 2003	Depart Prosser; Arrive Washington State University, Mt Vernon for WSU Entomology Department Faculty Meeting
Tuesday 19 August 2003	Depart Mt Vernon; Arrive Washington State University, Prosser for review of HIPV research and completion of joint research manuscripts
Saturday 23 August 2003	Depart Prosser; return to Australia.

SECTION 3. REPORT BY DESTINATION

3.1 St Paul, Minnesota

The XV International Symposium on Chironomidae was attended by approximately 70 chironomid researchers from around the world. Whilst some were geneticists, the majority were ecologists working on either the use of chironomids in water quality assessment, or alternatively the management of pestiferous chironomids in agricultural or urban situations. This made the conference particularly relevant to my research, which focuses on ecology and management of pestiferous chironomids in NSW rice crops. The key papers presented in these areas are summarised below.

3.1.1 Key Papers - Rice Crop Production / Protection

The history, status quo and future prospects of chironomid study in China. Xinhua Wang, Ruilei Zhang, Yuhong Guo, Hongqu Tang, Zhen Liu and Chuncai Yan.

Xinhua Wang is Professor at the Department of Biology, Nankai University in Tianjin, China. Whilst Professor Wang's paper summarised much of the work so far conducted on chironomids in China, the area of particular interest that he covered was the role of chironomids as rice pests. The scientific literature on Chinese rice pests is fragmentary and, perhaps not surprisingly, mostly written in Chinese, making it fairly inaccessible to western researchers. Professor Wang has recently written several papers summarising this literature, and these have, for the most part, been published in the proceedings of previous chironomid symposia that I have not attended. Consequently I was unaware of Professor Wang's work, and I have recently contacted him to obtain copies of his articles. These should prove invaluable to our work in NSW, as several chironomid species of potentially damaging chironomids are found in both China and NSW.

Chironomid-hydroperiod relationships in Everglades National Park. Richard E. Jacobsen and Sue A. Perry.

Ric Jacobsen has been looking at the effects of water regulation on chironomid communities in the Everglades National Park. The agricultural significance of this work relates to the fact that the seasonal wetting and drying cycles that occur in parts of the Everglades are essentially analogous to those caused by the annual flooding of rice fields in NSW. In addition, Ric has recently found *Polypedilum nubiferum* (Skuse) in the Everglades wetlands. *P.nubiferum* is one of the most common chironomids in

NSW rice crops, and is a potential source of damage during the later part of crop establishment. Whilst it has been known from Hawaii for some years, Ric's records from the Everglades are the first from the continental United States. Ric is examining how environmental conditions influence recruitment of *P.nubiferum* and other species in wetlands, and his ongoing work on the colonisation biology of *P.nubiferum* is likely to provide useful information on what influences the colonisation patterns of the species within Australian rice crops.

The state of Chironomidae palaeoecology in Australia. Sophia Dimitriadis and Peter S. Cranston.

Sophia is a PhD student under the supervision of Professor Peter Cranston at UC Davis. Sophia works on the use of chironomid remains in lake sediments to infer previous environmental changes. This work has little obvious agricultural application, however what caught my attention during this paper was the technique Sophia used to present her data, and I discussed it with her after the session concluded. Palaeoecologists have developed special graphics programs, such as PanPlot and Tilia, to generate vertical graphs showing how the composition of plant and animal communities has changed over time, based on the recovery of animal remains, pollen, etc. from sediment cores. These programs provide good graphical representations of data at different times from a known 'start point' – typically the present time in palaeoecology studies. This approach to data visualisation has considerable application to colonisation studies being conducted on rice field chironomids, where the 'start point' can be given as the day of field flooding. The PanPlot program is freeware, available from http://www.pangaea.de, and I have downloaded a copy which I am currently evaluating. I anticipate it will be extremely useful – although the fact that the user's manual is only available in German has led to some minor difficulties.

Control of pestiferous emergences of Chironomidae: a case study of *Polypedilum nubiferum*. Martin B. Berg, Arshad Ali and Richard W. Merritt.

Martin Berg from the Department of Biology, Loyola University, Chicago, has been investigating nuisance emergences of *P.nubiferum* from lagoons in Hawaii. The lagoons fill from sugar cane field drainage, and remain full for six to eight months each year, during which time swarms of adult midges are attracted to lights at nearby condominiums, causing a nuisance and triggering allergic reactions in some residents. Considerable effort was directed towards identifying areas of high larval density within the lagoons, which where then treated with experimental applications of either methoprene (a juvenile hormone analogue) or the bacterial insecticide *Bacillus thuringiensis israelensis* (BTI). The methoprene was effective, however BTI was not, probably because the low application rate approved by the USEPA for the trial work was below the minimum requirement for effective control. I suggested that the problem might resolve itself if nutrient flow from the cane fields could be reduced, however it appears, based on Martin's work, that nutrient levels in the lagoons are extremely low. This contrasts to situations I have encountered in Australia, where large numbers of *P.nubiferum* emerging from lake systems were clearly related to major influxes of nutrients, such as fertiliser runoff from golf courses. Work at Yanco is currently focussed on developing BTI for use against rice field chironomids, however we are targeting a *Chironomus* species, rather than *Polypedilum*, and our shallow water conditions are allowing us to achieve effective control at rates below that used in the (comparatively) deep-water Hawaiian study. Methoprene is inappropriate for use in rice fields because it induces mortality at the pupal stage, effectively preventing adult emergence but not preventing the larvae from damaging rice seedlings during development.

20,000+ references are waiting for you. Odwin Hoffrichter.

Odwin Hoffrichter from the University of Freiburg, Germany, has spent a large amount of his career building a bibliography of all scientific work conducted on chironomid midges. The problem he faces now is how to distribute this database effectively whilst receiving some recompense for his effort. Thus far, the database has been distributed only as hard copy annual updates, effectively making it unavailable for electronic searching. Even in its complete form, the database is only in MSWord format, which, while searchable, is not an appropriate format for use in reference database programs such as ProCite or EndNote. Whilst it would be ideal to have the database re-entered using ProCite format, this is unlikely to happen, and the best option would appear to be licensing downloads of the full MSWord file from a central server, with advance payments being made by subscribers in exchange for a licence number necessary to initiate the download process. Odwin is negotiating with the information technology people at his university to see if this is a viable means of selling database access.

Designing efficient sampling plans using a spatio-temporal Chironomidae (Diptera) larval distribution model. Richard J. Lobinske and Arshad Ali.

Richard Lobinske and Arshad Ali are both from the University of Florida at Apopka, adjacent to several large lakes where swarms of adult chironomids cause ongoing nuisance problems for local residents. The majority of these problems were caused by high levels of nutrients entering the lakes from both urban and agricultural areas, and the nuisance problem has abated substantially since steps were taken to reduce nutrient inputs. Midges still cause sporadic problems, and this paper was directed towards determining how best to quantify larval populations in different areas of the lake so that BTI and insect growth regulating compounds could be used most effectively. The lakes are too large to be treated in their entirety.

Exhaustive sampling of larval populations was undertaken across several years and large quantities of environmental data (sediment type, nutrient loadings, water temperatures, etc.) were collected and used in the construction of a computer model that predicts larval densities in different parts of the lake during an average yearly cycle. The model has been shown to be over 90% accurate, allowing operational midge control staff to achieve the best possible outcome using the minimum amount of chemical intervention. Whilst this modelling approach may have limited application in agricultural situations such as rice (where environmental conditions are largely uniform across fields due to relatively consistent water depth), it demonstrates how large data sets can be used to predict pest occurrences on a landscape scale, a process that has broad application to pest management in a range of cropping situations.

Influence of selected sediment physical parameters on spatial distribution of larval *Glypotendipes paripes* (Diptera: Chironomidae) in three central Florida lakes. Richard J. Lobinske, Arshad Ali and Robert J. Leckel, Jr.

This paper arose through the data collection process for the computer modelling of chironomid distributions discussed previously, and demonstrated how larval *G.paripes* densities were highest in areas of sediment dominated by particles of a particular size range, and containing the highest levels of organic nutrients. The principle question posed by this paper is how these differences in larval densities arise, since the adult female midges have no effective way of sensing the sediment characteristics of the floor of the lakes when they oviposit into the surface waters. Presumably the pelagic first-instar larvae actively seek out the most favourable sediment type before settling and tube formation, however the variation in densities may also be influenced by differing levels of larval survival mediated by food availability.

DNA profiling for biomonitoring of aquatic ecosystems. David Sharley, Vin Pettigrove and Yvonne Parsons.

The genus *Chironomus* causes considerable problems for researchers, both in Australia and overseas, because the larval stages of different *Chironomus* species are virtually indistinguishable. A larval key to the Australian species of *Chironomus* has been developed by Jon Martin from the University of Melbourne, however this key is not entirely reliable: much of it depends on measurements of abdominal structures, and these vary within species when they develop under different environmental conditions. These researchers, from Latrobe University and Melbourne Water Corporation, have developed a DNA-based test that appears to be a highly reliable method for identifying larvae of different Australian

Chironomus species. It remains to be seen whether this technique can be developed into an easily used laboratory test that can be applied by non-specialists, and if so, at what cost. The other drawback to using DNA testing to differentiate *Chironomus* larvae is that the samples must be properly handled and preserved if the DNA is to be recovered for analysis. Nevertheless, it represents an interesting approach to a fairly intractable problem in chironomid taxonomy, and it is refreshing to see molecular biology come up with a potential answer to a practical problem in basic insect taxonomy.

3.1.2 Key Papers – Environmental assessment

Whilst the symposium involved a reasonable number of papers with implications for chironomid control in rice, and also in non-agricultural systems, many more papers were given by researchers with an interest in using chironomid community structure to characterise rivers and lakes, and monitor changes in water quality. This is not unusual, since chironomids are amongst the most abundant and diverse groups of aquatic insects, with some species showing high levels of vulnerability to environmental change. Of particular interest at this symposium was the number of European researchers presenting papers in this area – apparently a European Union directive has been issued requiring all EU countries to document the health of significant waterways, and this is generally being done, at least in part, through studies on invertebrate biodiversity. Massive amounts of funding have become available to support this work, and this was reflected in the large number of European delegates attending.

The overall themes of many of these environmental assessment papers were broadly similar – chironomid and environmental sampling followed by some form of multivariate data analysis to group water bodies (mainly rivers and streams) into categories varying from 'pristine' to 'highly degraded'. The process essentially determines benchmarks against which progress in environmental restoration can be measured in the future. There were three main reasons why these papers were of interest. Firstly, the studies of lotic European environments were detecting remarkably high levels of chironomid diversity, with 50 to 80 species commonly being recorded from the more pristine mountain streams. This level of diversity in extremely high compared to that recorded in lentic agricultural environments in Australia, which, admittedly, generally contain less habitat niche diversity, are often high in nutrients, and may also be contaminated with agrochemical residues. The second notable feature of these studies was the level of taxonomic resolution that could be relatively easily achieved with European chironomids. The taxonomy of European chironomids is very well known, and it is not so much a question of whether a researcher can identify chironomid pupae and larvae to species level, but rather which one of several available keys the researcher uses to achieve this result.

This contrasts strongly with the situation in Australia, where the poor support given to taxonomy (and the consequent scarcity of taxonomists within scientific institutions) has resulted in many Australian chironomids (and insects in general) remaining undescribed. Whilst species in some Australian chironomid genera can be identified, in many cases the best that can be achieved is generic level identification, and in some cases even generic identifications of Australian taxa can only be regarded as 'provisional'. Our knowledge of our own invertebrate fauna lags far behind that prevailing in Europe and North America, and it is a sad contradiction that, in Australia, we have so willingly embraced the concept of biodiversity whilst simultaneously driving taxonomists, the chroniclers of biodiversity, to the brink of extinction. Because taxonomy generally doesn't attract external funding, and does not offer the tantalising promise of intellectual property revenue, it has tended to 'fall through the cracks' in terms of public science funding in Australia.

The third area of interest in these papers involved the multivariate analysis techniques that were chosen by the various researchers. Principal component analysis, detrended correspondence analysis and multidimensional scaling had all been used effectively to resolve separate groups of waterbodies with similar faunal communities, with detrended correspondence analysis probably the most frequently used technique.

The main papers of interest are listed below. They have not been summarised separately because of the overall similarities in their general themes.

Ecology and distribution of chironomids in mountain streams in the Italian Alps. Valeria Lencioni, Bruno Maiolini and Bruno Rossaro. Department of Invertebrate Zoology and Hydrobiology, Natural Science Museum, Trento, and Department of Biology, Section of Ecology, University of Milan, Italy.

Using chironomids as indicators in implementing the EU water framework directive. Xavier-Francois Garcia, Mario Brauns, Martin Pusch and Norbert Walz. Leibniz-Institute for Freshwater Ecology and Inland Fisheries, Department of Lowland Rivers and Shallow Lakes, Berlin, Germany.

The use of chironomid pupal exuviae for monitoring water quality on the island of Madeira. Samantha Jane Hughes and Declan A. Murray. Laboratório Regional de Engenharia Civil / Centro de Estudos de Macaronesia, Universidade de Madeira, Funchal, Portugal, and Department of Zoology, University College, Dublin, Republic of Ireland.

Reconstructing lake chemistry from pupal skin training sets. Leslie P. Ruse and Stephen J. Brooks. Environment Agency, Reading, and Department of Entomology, Natural History Museum, London, UK.

The chironomids of the Taro River, Italy. Laura Marziali, Carlotta Casalegno, Giorgio Hanozet, Guiseppe Parenti, Matilde Forcella, Elisa Berra, Roberto Giacchini and Bruno Rossaro. Department of Biology, Section Ecology, and Department of Environmental Sciences, University of Milan, Italy.

3.1.3 Monitoring of Water Quality in Minnesota

During the course of the Symposium a 1-day excursion was held, which had as its main focus a review of water quality monitoring programs conducted primarily by community volunteer groups, but assisted by State government funding and given technical support by staff of the University of Minnesota.

Minnesota has an extensive network of rivers, including many, like the Mississippi and St Croix, which are of national significance. There are also literally thousands of lakes spread across the state, which are important wildlife habitat as well as representing a major recreational resource for the community. There is a very high level of public awareness about the value of these resources, and also a very high level of community involvement in water resource management. The Minnesota Pollution Control Agency (MPCA) (www.pca.state.mn.us) is at the forefront of organising the monitoring of Minnesota waterways, and promotes itself as a 'one-stop-shop' for all relevant information on the subject. The organisation conducts its own monitoring, but also serves to coordinate the Citizen Lake-Monitoring Program and Citizen Stream-Monitoring Program. Within individual counties part-time salary funding is provided for coordinators who organise volunteer groups and train them in appropriate monitoring techniques to ensure the required protocols are met. This ensures that the data obtained by individual groups is of a standard adequate to be used within MPCA reports. This is a key feature of the volunteer programs – people are trained to generate useful data that supplements that generated by full-time environmental scientists. It is a genuine partnership, and not a once-a-year publicity exercise to raise the profile of the MPCA.

The volunteer programs are heavily supported by researchers from the University of Minnesota, the USEPA, County Environmental Services, and other State and Federal agencies. Taxonomists prepare identification guides to aquatic invertebrates and ecologists devise sampling plans that are printed as field guides for the groups. Invertebrate samples have to be retained for 7 years after collection in case there are doubts raised as to the validity of identifications. Hydrologists devise sampling plans for turbidity, conductivity, and other parameters that are incorporated into the protocols.

The Citizen Monitoring Programs are a prime example of how volunteer groups can be encouraged to effectively interact with government for mutual benefit, and similar systems could be established in Australia, at least in areas where the population base is sufficient to provide an adequate number of committed volunteers. The system is not, however, without it problems. The main difficulty is in maintaining volunteer enthusiasm, year-in and year-out. To some extent this problem is overcome by incentive gifts (ie, a clip-board after 6 months involvement, a sweatshirt after 12 months, etc.), but this only partly solves the problem. Many volunteers imagine that the program will lead to the discovery of major acts of environmental vandalism, the perpetrators will be caught, and they will be famous – the reality is, however, that groups can monitor healthy water bodies for many years without finding any noticeable change in environmental variables at all, let alone any that could be related to, for example, illegal waste discharges.

A major plus for the scheme, however, is the immense level of financial support that it receives. One site I visited originally contained a spring creek that had been dammed to create ponds for rearing baitfish. The community group decided that the site should be rehabilitated. The state bought the land, demolished the ponds, and funded the volunteers to locate the original path of the waterway. Heavy machinery was used to excavate the stream bed, then the volunteers revegetated the banks, positioned snags in the creek, and even lined part of it with river gravel to assist colonisation by native invertebrates, provide spawning sites for Brook Trout (a threatened native species in Minnesota), and limit any initial erosion. This rehabilitation project is progressing extremely well, however it would not have been possible without large amounts of government money.

3.2 Mt Vernon, Washington State

3.2.1 Structure and Management of WSU Entomology Department

The purpose of attending the Washington State University Entomology Faculty Meeting was primarily to make contact with several WSU researchers that are normally spread across a number of campuses in various parts of the state. Despite this being the main objective, the meeting (which was substantially administrative) was valuable in its own right, in that it provided valuable insights into how major USA university departments are run, and the problems they have to contend with. The program for the meeting is given on the following page.

The Entomology Department at WSU has approximately 25 academic staff – slightly more than the total number of entomologists employed by NSW Agriculture. Many of the problems experienced by the department are broadly similar to those experienced by NSW Agriculture researchers, although there are some problems that appear to be unique to the USA. Declining infrastructure is a major issue, with satellite research campuses (like Mt Vernon) being in drastic need of renewal. Many of the buildings at Mt Vernon date back to the 1940's, and some are currently being replaced, however sourcing funds for reconstruction is a major problem. Washington State has the third highest level of unemployment in the United States (after Alaska and Oregon), which I found surprising – I would have guessed that unemployment would have been worst in the southern states, but this is not the case. High levels of unemployment and the associated financial burden on the community has become the major focus of state legislators, and renewal of university infrastructure is a long way down the list. The university is constantly being pressured to increase student fees as a means of raising revenue for infrastructure renewal, however experience has shown that in science, increasing student fees results in declining enrolments, as students either opt for more lucrative careers, or enrol at different universities with lower course fees. This can lead to a downward spiral that ultimately results in declines in staffing, declines in research output, and sometimes the dissolution of entire university departments. The Entomology Department at Oregon State University has recently been disbanded, but I am not sure to what extent this relates to declining enrolments in response to increasing course fees.

A somewhat more unique problem being experienced by WSU researchers at present relates to what are known as the "Commodity Commissions". These state-based organisations are more or less equivalent to our various research "Corporations" (GRDC, HAL, RIRDC etc.), in that they coordinate the collection of production-based research levees from growers and then distribute the funds to successful grant applicants, either within universities or to other research organisations such as the USDA.

The problem is that grower groups across several rural industries are actually taking legal action against the Commodity Commissions in order to recover their levee money. Basically, they do not want to pay for research into improving their own production systems. This is not to imply that the growers are 'anti-research', or that they think their current research providers are not doing a good job. Far from it. What they want is for government to fund existing and future research programs at 100%, without any grower contributions. So far several court cases across the USA have led to the return of grower levees, and, in general, public money has not been forthcoming to pick up the shortfall in research funding. There appears to be a major stand-off developing in many states between particular industries and government, and as per usual it will be the research providers stuck in the middle who will suffer the most.

A major component of the meeting related to staff tenure and promotional cases, and highlighted the way WSU (and most American universities) apportion their staff to different duties – teaching, research, and extension. I believe NSW Agriculture can learn valuable lessons from the way their staff duties are structured, and the way in which tenured positions are obtained within WSU.

Staff appointments to WSU (and most American universities) are made on a 'provisional' (ie, non-tenured) basis, and staff have a certain period (several years) in which to be granted tenure. In order to obtain tenure, they have to be 'awarded' it by the existing tenured members of the department – peer review, in other words. Staff members must give seminars annually to the full department, submit progress reviews on a regular basis, and if an application for tenure is not made and approved by the due date, then their position terminates. End of story.

This seems to be an excellent method of staff recruitment and quality control that could be applied to science-based state agencies in NSW. At present, researchers are appointed in NSW Agriculture on the basis of 'provisional' appointment, confirmed after 12 months, however confirmation of an appointment does not really require any real demonstration of productivity. Provided you don't commit any significant indiscretions, appointments seem to be invariably confirmed. It is my belief that appointment to a 'permanent' position should require evidence of significant productivity and scientific rigour over a tenure application period.

This requirement would go a long way to improving organisational productivity and promoting a culture of excellence in state science agencies, but there are clear obstacles to implementing it in the NSW public sector. What the unions would think of it remains to be seen. A more fundamental problem, however, is the resource base of scientists in Australia that we can select from, and the level of remuneration that we provide relative to other agencies. Salary structures for PhD-qualified researchers in NSW Agriculture (and other state agencies) are generally lower than those at, for example, CSIRO, which is considered (correctly or otherwise) to be a more 'prestigious' research agency. Admittedly the gap has narrowed in recent years, but if we combine low remuneration levels with rural locations and a highly rigorous process of obtaining tenure, will the net effect be to reduce the number of applicants we get for advertised positions? Does a rigorous tenure process discourage good scientists from applying for positions, or does it only discourage the unproductive ones? Is this an issue we can live with if the end result is that we avoid filling permanent positions with unproductive individuals? A lot of questions here with few answers that I am in a position to provide, but it is certainly food for thought in a situation where there are increasing budgetary pressures on NSW Agriculture to do more with less.

One structural arrangement prevalent in US universities that could be implemented in NSW Agriculture with considerable benefit to both staff and management is the formal apportionment of positions to different work areas. As can be seen from the meeting agenda, many staff at WSU occupy positions that are divided into different areas, primarily research, extension and teaching. An individual may have a position that is 0.75 research / 0.25 extension, or some other combination. This sort of job classification could be applied to research and extension staff within NSW Agriculture, and would have several important benefits.

At present, research and extension staff within NSW Agriculture are formally classified as just that – either they are 100% research, or 100% extension. This is rarely the case in practice, however. Most, if not all researchers are involved in some extension activities (or should be), whilst many extension staff assist researchers with district trials and similar activities. The essential problem with the current situation is that management has no flexibility in recruitment – we either hire a researcher or an extension officer (or both), when perhaps a 0.75 research / 0.25 extension person would be the best way to respond to industry requirements whilst still balancing the budget. A further problem is that staff are given no real recognition for activities outside their 'home' area. This is particularly true of more highly-ranked researchers. Extension work is important particularly for their industry (and funding body) profiles, however it seems not to be given much credit by the Research Scientist Qualifications Committee.

Whilst the idea of fractional research/extension appointments has considerable appeal, it also has problems. Can we consistently attract individuals with the requisite skills in both research and communication? Should such a system be applied to existing staff, or only to new staff members? If the former, existing staff should be classified by mutual consent, and the fractional status of permanent staff should likewise only be subsequently adjusted by mutual consent, otherwise it could potentially be seen as a move to limit career progression by 'moving the goalposts'. How would fractional appointments affect job progression? Which positions can access the Research Scientist Classification, and would positions other than 1.0 research receive appropriate treatment? Once again, an idea that has many benefits also has many questions associated with it, but it does provide food for thought. It should be noted that in the American system fractional appointments have not led to a 'teaching and extension underclass'. All academic staff are recruited at PhD level, and their salaries and progression are equivalent, regardless of what proportions of their time are spent on research, teaching and extension. Individuals that are 1.0 teaching or 1.0 extension can and do reach full professor status.

As with any large organisation, politics and personality play a key role in the success of the WSU Entomology Department. Professor John J. Brown has done an excellent job during his term as Chair of the Department, and without exception the staff members want him to stay on for another term. Professor Brown, however, wants to return to his research, and there are few other individuals within the Department willing to take on the role. Most of those that are willing are located at satellite campuses and want to run the Department from their current location, rather than move to the main campus at Pullman. This appears to be untenable, whilst the only person interested who is actually on the main campus appears not to be suitable. The basic problem is that the levels of remuneration given to Departmental chairs are not substantially greater than those they can obtain in their non-management academic positions, and therefore there is insufficient incentive for potentially good managers to move away from their (predominantly) research duties and into management roles. This is a common problem across organisations, and is paralleled in NSW Agriculture, where a Program Leader is paid less than a researcher on the top of the Senior Research Scientist scale.

3.2.2 Discussions with Researchers

The main reason for attending the WSU Entomology meeting was to make contact with two researchers from other WSU campuses, Dr Steve Clement, from the USDA at WSU Pullman, and Professor John Stark from WSU Puyallup.

Dr Clement completed his PhD at the University of California, Davis, in the mid-1970s, and is one of relatively few scientists worldwide to have worked on the role of chironomid midge larvae (bloodworms) as pests in establishing rice crops. Since that time he has become a world authority on the conservation of crop plant biodiversity and the use of plant genes from indigenous crop varieties to confer pest and disease resistance to commercial plant cultivars.

Dr Clement put forward several interesting theories as to why chironomids are only sporadic pests in Californian rice fields. Foremost amongst these is the idea that time of planting has a significant impact: early-sown rice crops tend to experience less damage than late-sown ones. I was keen to discuss this with Dr Clement and find out what the basis for this would be. In Californian rice crops pesticides are not widely used for chironomid control, nor were they when Dr Clement conducted his research. This led to early-sown rice fields acting as breeding areas for pestiferous midge species, which emerged and then infested crops sown later in the season at far greater densities, leading to levels of damage above economic thresholds. This multiplier effect was exacerbated by the fact that some of the pest species have multiple overlapping cohorts within each field. In addition, warmer water conditions in late-sown crops lead to higher levels of larval activity and faster development to reproductive maturity. In Australia, the situation is rather different. All aerially-sown crops are treated for bloodworm at sowing, effectively eliminating these areas as reservoirs for the development of *Chironomus tepperi*, the main pest species in Australia. *C.tepperi* will only oviposit in newly-flooded environments. Date of sowing therefore plays a very limited role in the severity of *C.tepperi* infestations in Australian rice fields; what seems to be more important is the weather conditions in the 2 to 3 months leading up to rice sowing. If there are regular and significant rainfall events in this period, roadside pools and similar ephemeral habitats flood and, since they are not chemically treated, act as areas for population increase. Adults emerging from these non-rice habitats then oviposit into the rice fields. This explains why crops sown after a very dry winter usually support only low *Chironomus tepperi* densities.

Dr Clement is heavily involved in the management of plant genetic resources, and the use of genes from wild plants related to commercial crops as a source of insect resistance. These genes can normally be incorporated through conventional plant breeding, and it was therefore interesting to get his views on the use of genetic engineering to produce highly modified plants containing bacterial toxin genes, such as those from *Bacillus thuringiensis*. His general view is that the American public, for the most part, are largely unconcerned about genetically engineered crops, and this attitude is as much due to simple lack of interest as lack of information. A further aspect is that the American public tend to rely on massive government agencies to make judgements on their behalf, and if the NRA or the FDA say that a particular product or practice is safe, then the vast majority of the public are happy to accept the government decision. The level of scepticism of government agencies in the USA seems to be far below that expressed by the Australian public in regard to equivalent agencies here. Dr Clement was of the view, however, that genetically modified crop plants are generally being created for commercial reasons, or simply because they can be, rather than because they are actually needed.

Dr Clement is a session organiser for the XXII International Congress of Entomology, to be held in Brisbane in 2004. I am organising a symposium on rice pest management within the session Dr Clement is coordinating, so the opportunity to discuss aspects of the congress was extremely beneficial. During the course of the Mt Vernon meeting I gave a 30 minute presentation on the Brisbane Congress, based on a PowerPoint presentation I obtained from the congress organisers. The presentation was well received and may influence additional WSU staff members to attend the Brisbane meeting.

Professor John Stark is based at the Puyallup campus of WSU near Seattle, and is a leading researcher in the field of aquatic toxicology. He has worked extensively on the theoretical basis of whole organism toxicology and published extensively in leading journals. His work mainly involves *Daphnia* and related genera of water fleas. He is interested in the effects of agricultural chemicals on the survival, growth and reproduction of invertebrates, an area that is highly relevant to my work supervising ecotoxicology students supported by the CRC for Sustainable Rice Production.

Discussions with Professor Stark revolved around his life-table approach to chronic toxicity testing, an intuitively highly sensitive procedure that relies on monitoring test organisms through several full generations after they are exposed to a potential toxicant. Whilst this approach to chronic toxicity testing appears to be potentially valuable, it has not been extensively embraced by testing laboratories that normally test organisms through only a single generation. The reasons relate to cost and throughput - chronic toxicity testing cannot be extensively automated and is highly labour-intensive, and a 3-generation test will cost 3 times as much as a single generation one. Throughput of compounds would logically also be cut by two-thirds.

The use of *Daphnia* in Professor Stark's research program confines the testing process to the water phase of soil / water systems - since *Daphnia* are pelagic, they do not experience any exposure to toxicants potentially bound to sediments. Chironomid midges, which have burrowing larvae, would be better indicators of sediment toxicity, and Professor Stark and I discussed the possibility of collaborating to test his life-table approach using *Chironomus tepperi*. Studies on the toxicity of adjuvant chemicals (surfactants, etc.) to chironomids are also being considered.

3.3 Prosser, Washington State

3.3.1 Evaluation of HIPV research

Associate Professor David James moved to WSU several years ago after a long and distinguished career with NSW Agriculture, where he worked on citrus, grape, and pasture pests. He is currently involved with grape and hops research, and also works in several minor crops, such as redcurrants. He is now specialising in insect pheromone research and the use of herbivore-induced plant volatiles, or HIPVs. The facilities available to Dr James at Prosser are quite outstanding, and to a large extent reflect the close relationship between industry and research providers in the USA. Construction of his hops entomology laboratory was funded entirely by the makers of Budweiser beer.

The rationale behind HIPVs is relatively simple. Plant chemists have found that certain crop plants, when attacked by herbivorous (pest) insects, emit a range of chemicals in response to the attack. The chemicals vary between plant species, and their release cannot necessarily be triggered by deliberate plant mutilation - for example, HIPVs that may be associated with lucerne may not necessarily be released by mowing the crop for hay production. There is a substantial body of evidence that some beneficial insects are attracted to HIPVs, and attack the pest species. HIPVs are essentially a 'cry for help' from some crop species under attack by pests.

HIPVs that have been identified so far include methyl salicylate (the chemical that gives Dencorub® its odour), *Z*-3-hexenyl acetate, 3*E*-4,8-dimethyl-1,3,7-nonatriene and 3*E*,7*E*-4,8,12-trimethyl-1,3,7,11-tridecatetraene. The question is, how can HIPVs be used to enhance pest management?

In recent years a major emphasis has developed on reducing the amount of insecticides used in agriculture. One of the most effective ways of doing this is through biological control. Many of the most dramatic examples of the usefulness of biological control tactics involve the introduction of exotic predators to control introduced plants (such as *Salvinia* and prickly pear), but the introduction of exotic insects, no matter how thoroughly they are screened, always involves some level of risk. A safer alternative is to look at ways to enhance populations of native predators that are already present in Australian cropping areas.

If a given HIPV is attractive to a beneficial insect, then lures containing that HIPV may be effective in attracting more of those beneficials into a given crop. Alternatively, if the crop needs to be sprayed with a chemical that may harm the beneficial species, then HIPV lures could be used to attract beneficials into adjoining areas, facilitating faster recolonisation of the crop after the residual activity of the chemical treatment declines.

Dr James' HIPV research is focussed mainly on wine grapes, however he is quick to point out that the techniques he is using are applicable to a wide range of broadacre and horticultural crops. He has found that methyl salicylate is the most effective of several HIPVs tested so far, and that it attracts a wide range of insects including predatory lacewings and ladybirds. His initial studies focussed on testing candidate HIPVs using a range of trap types. This is an essential first step in any cropping situation to determine which insects respond to which compound. He is now working at the whole-vineyard scale, using slow-release methyl salicylate sachets to determine whether predator numbers can be increased relative to populations in control (untreated) vineyards. If successful, there may be opportunities for commercialisation of the sachets he is using. Whilst yellow cards are now being used for monitoring predator numbers, he pointed out that other trap types may be useful for separating the attractant effects of the HIPVs from the normal attractant response that many insects show to yellow cards.

Whilst with Dr James, I examined his trapping protocols and have developed suitable trial strategies for evaluating selected HIPVs in both citrus and grapes in the Riverina. The technique may also be useful in broadacre crops, such as rice and canola, however it should first be evaluated in a crop like citrus because many citrus orchards are not reliant on the use of broad-spectrum insecticides that may adversely affect populations of beneficial insects.

3.3.2 Collaborative publications

Dr James and I made substantial progress on 2 collaborative publications while I was at Prosser. A paper on midge colonisation patterns was prepared for submission to the refereed journal *Hydrobiologia*, whilst substantial progress was made on a paper on the effects of ground cover on ant communities within citrus orchards. This paper is being prepared for *Australian Journal of Agricultural Research*. At present manuscript revisions are being exchanged by email with Dr James, who will be a co-author on the ant paper, along with Dr David Madge of Agriculture Victoria, who conducted one of the two ant trapping programs.

SECTION 4. BENEFITS OF TRAVEL – M.STEVENS

Undertaking this trip has been of substantial benefit to me, as it has helped me to keep up to date with the latest developments in chironomid research and management that are relevant to rice production in NSW. As the only rice entomologist currently active in Australia, it is difficult for me to have much close interaction with my peers unless I get the opportunity to travel internationally.

This trip has placed me in a better position to develop research proposals designed to maintain the NSW rice industry at the forefront of both productivity and responsible pest management. There are also opportunities to use the knowledge I have gained to improve production practices and environmental outcomes in horticultural crops through the evaluation and development of HIPVs for enhancing populations of beneficial insects. Particular areas of work that, as a consequence of my travel, I believe deserve increased emphasis include:

- Development of environmental assessment protocols based on chironomid midge communities. The diversity of chironomids within rice fields and associated habitats, and the sensitivity of some species to environmental contaminants, makes them an ideal group to use in assessing the environmental impact of crop management procedures, both within crops and elsewhere within irrigation systems. This usefulness is reflected in the use of chironomids in water quality studies currently being conducted in many European countries.
- Evaluation of chironomid species other than *Chironomus tepperi* as potential rice crop establishment pests. Chinese studies have implicated *Polypedilum nubiferum* as an important rice pest, however simple feeding studies conducted in NSW refute this suggestion. More sophisticated testing techniques are required, and techniques such as ELISA, fluorescent proteins, and DNA-

based techniques should be developed to resolve this issue, both in relation to *P.nubiferum* and other common species.

- A review of the world literature on chironomids as crop pests is urgently required. At present the literature is fragmentary - whilst there are many detailed studies from countries such as Australia, Italy and the USA, there is also a large body of smaller papers available from countries such as China, Romania, Japan, and various states of the former Soviet Union. Language problems will make assembling the literature into a comprehensive review both time consuming and difficult, however an attempt needs to be made, preferably in collaboration with other workers who can contribute both technical and linguistic expertise.
- Development of a testing program to determine which beneficial insects respond to HIPVs, and therefore whether compounds such as methyl salicylate have potential for use in pest management systems in Australia. Whilst initial testing should be conducted in horticultural crops, positive results could have implications for broadacre industries, including rice.

Establishing and strengthening links with other researchers will assist me in the development of collaborative projects of international significance. Additional collaborative studies with Professor Ali (Florida) are likely to be developed, and collaborative projects with Professor Wang (China) are also a possibility. Due to my current commitments to RIRDC and Rice CRC projects, these new collaborative projects are likely to be initiated in the medium to long term, rather than in the immediate future.

SECTION 5. BENEFITS OF TRAVEL – NSW AGRICULTURAL INDUSTRIES AND NSW AGRICULTURE

NSW agricultural industries will benefit from the knowledge, experience, and contacts I have gained whilst overseas, as this information will be used to:

- Formulate and conduct research programs aimed at assisting the rice and citrus industries to reduce inputs of broad-spectrum insecticides, thereby improving environmental sustainability and reducing production costs.
- Design and conduct research that will identify risks to non-target organisms caused by the use of particular agrochemicals, and develop techniques for minimising these risks.

SECTION 6. RECOMMENDATIONS

Recommendations to NSW agricultural industries arising from my travel are outlined below.

- Attention should be given to the development of research proposals aimed at determining the selectivity of rice bloodworm control treatments to *Chironomus tepperi*, the principal pest species attacking rice in NSW. Many of the bloodworm control treatments currently in use are likely to be killing a broad range of aquatic insects that are actually beneficial to the crop. Farmers have chosen these treatments in preference to more advanced approaches for many years, primarily due to their low cost, however in so doing they have potentially had a detrimental effect on invertebrate food chains within the rice agroecosystem. Because of the importance of aquatic food sources to terrestrial food chains, growers may obtain a greater benefit from more selective materials which, although potentially more expensive, may allow better conservation on non-target species. This will lead to higher in-crop biodiversity and ultimately greater populations of both aquatic and terrestrial predators that will provide better natural control of pests such as mosquitoes and armyworms.
- The NSW rice industry should support research directed towards developing a better understanding of the feeding behaviour of chironomid larvae within rice fields. Extensive research on *Chironomus tepperi* has been conducted, and the biology of this pest is now reasonably well understood. There is, however, one major question that has yet to be answered - which of the other chironomid species in rice bays feed on rice? This is not purely a question of academic interest, but is of fundamental

importance to control programs. Extensive studies have shown that *C.tepperi* has only one generation in rice fields, and does not recolonise. Yet growers often experience problems in the later stages of the crop establishment period, necessitating the use of a second chemical application. It is not known which species are damaging the crop at this stage, nor their level of susceptibility to the pesticides currently in use. This information is of critical importance if further improvements are to be made in sustainable bloodworm management. For example, current research is being directed towards the bacterial insecticide BTI, and to the concept of inserting BTI toxin genes into rice. BTI sprays are known to be effective against *C.tepperi*, but the literature suggests they may be ineffective against *Polypedilum*. If this is the case and *Polypedilum* is feeding on rice, then the biodiversity conservation benefit of applying an initial BTI spray for *C.tepperi* control will be lost if *Polypedilum* colonises the crop and has to be treated with a broad-spectrum insecticide such as alphacypermethrin.

- A screening program to evaluate known HIPVs should be established to determine their potential usefulness to NSW agricultural industries. Initial studies should focus on the better known compounds such as methyl salicylate, and should be conducted in permanent horticultural plantings (eg. citrus and/or grapes) that are under low chemical input management regimes. Initially this research should be financially supported by NSW Agriculture, but once proof of concept has been obtained the relevant industries should be approached for funds for further development of enhanced pest management schemes utilising HIPVs.

SECTION 7. SUGGESTED DISSEMINATION OF THIS REPORT

Copies of this report will be distributed by the author to:

The Hon. Ian MacDonald, MLC, Minister for Agriculture and Fisheries.
Dr Richard Spurway, Deputy Chief, Division of Plant Industries and Program Manager, Field Crops, NSW Agriculture.
Dr Laurie Lewin, Director, CRC for Sustainable Rice Production.

Appendix 1. Abstract of Paper Presented.
XV International Symposium on Chironomidae, University of Minnesota, St Paul, USA.

COLONIZATION OF RICE CROPS BY CHIRONOMIDS IN SOUTHERN AUSTRALIA

Mark M. Stevens & Glen N. Warren
NSW Agriculture and Cooperative Research Centre for Sustainable Rice Production, Yanco Agricultural Institute, Private Mail Bag, Yanco NSW 2703 Australia

Larval chironomids are serious pests of establishing rice crops in New South Wales (NSW), Australia. *Chironomus tepperi* Skuse is known to cause extensive crop damage, and many aspects of its biology and management have been investigated. In contrast, there is almost no information available on the biology and pest status of other chironomid species associated with rice crops in NSW. This study was undertaken as a first step towards resolving this problem.

Chironomid larvae were sequentially sampled from small experimental rice bays at Yanco Agricultural Institute in southern NSW. Sampling was undertaken during the 1995, 1997, 1998 and 1999 crop establishment periods, starting 10 days after flooding (DAF) and continuing at 5 day intervals until 35 or 40 DAF. Eighteen species were identified from the 3,965 larvae recovered. The most abundant species were *C.tepperi* (0 to 91 % of 35 day totals), *Procladius paludicola* Skuse (6 to 78%) and *Polypedilum nubiferum* (Skuse) (1 to 12%). No other species accounted for more than 8% of recovered larvae in the first 35 DAF of any year. Species richness increased progressively during the first 25 DAF and then started to plateau. *C.tepperi* colonized fields more rapidly than other taxa and, when present, had only a single generation. The abundance of *C.tepperi* varied dramatically from year to year: in 1996 it was totally absent, however in 1998 the peak density of *C.tepperi* larvae exceeded 13,000 m^{-2}. Application of multi-dimensional scaling and ANOSIM2 analysis (PRIMER) shows significant differences in community structure between post-flood sampling times (DAF, $P < 0.01$) and also between years ($P < 0.02$). Analysis of modified data sets (from which numerically dominant species were excluded) demonstrates that variations in *C.tepperi* abundance were the principle source of year to year variation in community development. Fluctuations in *P.paludicola* populations were the main source of differences between communities at different post-flood sampling times. Comparison of rice plant densities in the monitored bays to those in nearby bays receiving effective chemical protection shows that plant loss increased in response to higher *C.tepperi* populations.

2003 All Entomology Meeting
Washington State University
Mount Vernon Research and Extension Unit
Mount Vernon WA

Monday August 18

7:00-8:15 AM All American breakfast and coffee at hotel
8:30 AM Introductions, logistics of meeting, minutes from our 2002 meeting in Spokane
8:45 AM Tribute to Dr Carl Johansen (1923-2003)
9:00 AM 'Fresh look at some old questions'
  Laura Corley
  Allan Felsot
  Vince Jones
10:30 AM Comments from USDA-ARS (Landolt)
10:50 AM University of Tokyo opportunities (Corley)
11:00 AM International Congress of Entomology – Mark Stevens
11:30 AM Adjunct and affiliated faculty nominations
  Lars Crabo, Lepidoptera specialist, Bellingham, WA
  Merrill Peterson, Western Washington State University
    Bellingham, WA (Adjunct Faculty Status)
  Ekaterina Riga, IAREC, Plant Pathology (Nematologist)
    Prosser, WA (Affiliated Faculty Status)

Country Style BBQ on WSU Campus

1:00 PM Mount Vernon faculty members and brief tour of facilities
  Timothy Miller (848-6138 crops and soils)
  Debra Inglis (848-6143) and Lindsey du Toit (Plant Pathology)
2:00 PM Introductions to the Dean
3:00 PM State of the Department (Brown)
4:00 PM Discussion regarding Department Chair position (Brunner)
5:15 PM Happy hour and dinner, Cotton Tree Inn

Tuesday 19 August

8:00 AM Reports from non-tenured faculty members (optional, but welcomed)
  Catherine Daniels (promotion only)
  Carol Ramsay (promotion only)
  Vince Hebert (4^{th} year)
  William Snyder (4^{th} year)
9:00 AM Third year review
  Laura Corley 1.0 FTE research
9:30 AM Tenure and promotion cases
  Carol Sheppard 1.0 FTE teaching
  Douglas Walsh 0.75 extension and 0.25 research FTE
10:30 AM Promotion case
  W. Steve Sheppard 0.40 extension and 0.60 research FTE
11:30 AM Open discussion with all faculty members, followed by closed discussion of only tenured faculty members

Noon Closed meeting / working lunch

Adjournment