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Role of information and communication technology (ICT) in Entomology

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Internet has become the great potential to impact research, extension and teaching in Entomology. Scientists can communicate with their counterparts in other universities and research institutions. They can access a large database of information available on the net. Research literature is migrating very fast from paper to the web most of which can be accessed free of cost. It permits easy and efficient access of information thus saving a researcher's valuable time. Extension entomologists can access the latest information on pest control which can be disseminated to the farmers. Farmers can communicate directly with the expert for solution of their specific problem. Internet based communication is becoming more popular than making phone calls both among farmers and extension workers as it permits broader choice for the farmers and allows sufficient time for the expert to answer a query. Teachers can put their lecture notes on the institution's website to be accessed by students. Students can take practice tests on the institution's website, review and improve their performance.

Key words: Decision Support System, Entomology, Information Technology, Internet, World Wide Web

Introduction

Information needs are the basic requirements for the development of science. Any scientific institution needs to acquire information from diverse sources as well as disseminate the one generated by the scientific community. Immediate access to all scientific literature has long been a dream of scientists. The network information systems

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needed to support such access have steadily improved as underlying computing and communication infrastructure has improved (Schatz, 1997). Since, the past few years, internet has proved as an efficient and effective medium to easily find and access information. Although, it is relatively new, yet it has shown its tremendous potential as a source of information and medium of communication in a couple of decades and will affect our lives in a long way. The use of internet in entomology i.e. research, extension and teaching is in its infancy and it will witness a great impact in the years to come.

Internet and the world wide web (www)

The internet is a network system in which different computers are connected together by phone lines, fibre optic networks and Ethernet using the Transmission Control Protocol/ Internet Protocol (TCP/IP) suite. It was initially started in 1969 by United States Department of Defense as a communication network to survive any possible nuclear attack. A universal protocol for the internet was adopted in 1983 when all the research and government networks were connected (Howe, 1998). The development of World Wide Web (WWW) in 1991 gave a major impetus to the internet which was accompanied by the development of Hypertext Markup Language (HTML), as it allowed links embedded within text, enabling the user to access other text or files. The World Wide Web operates as a client/server system which is basically interactive. In this system, user/client sends a request to the server after thorough processing by a client program (browser). The server after processing the request of client sends back the result to him. The client program manages the request of the user and the data presented to him. The advantage of the client/server model lies in distributing the work so that each component focuses on a specialized task: the server distributes information to many clients whereas the client software for each user handles the individual user's interface and other details of requests and results (Bajwa and Kogan, 2003).

With the use of World Wide Web (WWW), users can access various documents e.g. texts, images, sound, video clips or softwares. It also integrates various other internet protocols *viz.* Instant Messaging, File Transfer Protocol (FTP), Telnet and e-mail. The World Wide Web operates on HyperText Transfer Protocol (HTTP), in which a number of documents are stored in countless number of computers all over the world. An institution or a person puts all its information on the web through web site. This information is presented to the user via. web

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pages, each page having its unique address i.e. Uniform Resource Locator (URL). Mostly the information in the web pages are in the form of text and images and sometimes sound and video.

Entomology and Internet

The use of internet in entomology research, teaching and extension is still in its infancy. Entomologists are now-a-days becoming increasingly aware of the impact of internet to accelerate their research. Internet tools help them communicate easily, find and access information faster than the traditional ways of finding the journals and taking photocopies of the articles. Teachers can find it as an effective teaching tool where the traditional text based lectures can be supplemented with photographs of insects and movie clips taken under natural conditions. Extension experts can also find it as an effective communication medium with the farmers to solve their problems.

The Internet and Research

The entomological research has witnessed a profound effect by the use of internet. Scientists are frequently using electronic mail (e-mail) and web as a faster means of communication than the traditional means. The use of e-mail encourages concise and well-thought-out statements compared to oral communication. E-mail attachments permit easy, efficient and faster transfer of manuscripts, data sheets and images. Similarly, File Transfer Protocol (FTP) allows quick and cheap transfer of very large files such as high resolution images and large databases. Through the use of e-mail, researchers can communicate with their counterparts at far off places to pursue joint projects. Literature search and acquisition as well as the research collaboration are the most impacted by internet (Leung, 1998). The most of the entomological information that was restricted to academic libraries and any institution's local area network (LAN) is now available online (Table 1). The journal literature is evolving very fast and sooner or later the entire corpus will be fully and freely accessible from the desk of any thinker in the world (Harnard, 1998). Both the open access Publishing and Open Access Archiving are central and crucial for any country especially the developing countries like India (Damodaram, 2009).

Literature search through internet is fast and efficient than going to library, finding the journal and taking photopies. A number of journals have started publishing their online versions. Although, some publishers charge for online access to the articles but most are available free on the net. For example, the Entomological Society of America charges $ 15 as surcharge for access to the online articles but the articles for which authors have purchased copyrights are available free at http://esa.catchword.org (ESA, 2007). On the other hand, online access to Bulletin of Entomological Research is free to those who subscribe to paper version (CABI, 1999). The access to Florida Entomologist published by Florida Entomological Society is free to anyone since 1994 (Fla. Entomologist, 1999). This free access will allow all the literature to become a web library which can be accessed by anyone at any time.

Most theses and dissertations will soon be posted on the web. Various universities and research institutions have become members of Networked Digital Library of Theses and Dissertations (NDLTD, 1999). Virginia Tech., headquarters to the NDLTD, has required submission of its theses and dissertations in digital form since 1997 (Young, 1998). Similarly, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana has made it mandatory for post graduate students to submit soft copy of their theses along with hardcopies as a part of rapid computerization of library. The library can be accessed at university homepage http://hau.ernet.in (CCSHAU, 2007). Punjab Agricultural University, Ludhiana, Punjab is also fast approaching towards computerization. SOUL software developed by INFLIBNET is operative in library since 2003 (PAU, 2009).

In addition to literature search, internet is also being used by researchers for collection and analysis of data and as a tool for publishing research articles in scholarly journals (Oblinger and Maruyama, 1996). A number of online databases are available on the web, which provide up-to-date information on a given topic. They can be used to access the latest information and to find gaps in the research to formulate new research proposals and to avoid duplicacy. A few examples of these databases include: The Pest Directory published by International Society for Pest Information (ISPI) available at http://www.pestinfo.org. It can be a useful database for scientists active in pest management as a reference for addresses and scientific literature (ISPI, 2002). It contains information on natural enemies and biological control products for agricultural pests, diseases and weeds as well as

medicinal and veterinary arthropod pests. The main strength of pest directory is the directory of organizations and scientists which have been obtained from the literature and from other sources. ISPI has made reasonable progress in achieving its goal of providing the most comprehensive directory of pest management in the world.

Another resource, the Crop Protection Compendium, produced by CAB International (CABI) (available online at http://www.cabi.org/compendia) is an electronic encyclopedia and database that contains a variety of information on crop protection. It encompasses not only pests, diseases and weed and their natural enemies but also the crops that are their hosts and countries where they occur. It is based extensively on the CABI bibliographic databases as well as on reports purchased from experts over the past 10 years. The initial focus and emphasis of the compendium is on providing the database to scientists in the developing countries (CABI, 2002). The Ecological Database of World's Insect Pathogens (EDWIP) (http://insectweb.inhs.uiuc.edu/pathogens/EDWIP/index.html) provides information on fungi, viruses, protozoa, mollicutes, nematodes and bacteria (other than *Bacillus thuringiensis*) infectious to insects, mites and other arthropods (EDWIP, 2007). It provides information on host range, countries and habitats where host-pathogen association can be observed. The resource by Insecticide Resistance Action Committee (IRAC) (http://plantprotection.org/irac) contains general as well as specific information about insecticide resistance, latest facts and the results of worldwide surveys (IRAC, 2007).

The Entomology Index of Internet Resources (www.ent.iastate.edu/list) is an online database of entomological resources from Iowa State University. It began in 1994 as a collaborative effort of John Van Dyk (Iowa State University) and Lou Bjostad (Colorado State University) to create a comprehensive central directory of internet resources of use to entomologists (VanDyk and Bjostad, 1999). Van Dyk continues to maintain the site, which has grown to over 1500 resources. Anyone can submit their online entomological resource to the Index, which stands as an example to the collaborative subject specific database. Scientists at the Kyushu University, Japan have developed a database (ELKUType) of type collection of insects which can be accessed by anyone by visiting the URL: http://konchudb.agr.agr.kyushu-u.acjp/elkutype/ (Tadauchi *et al.*,

2002). The database contains information about the scientific name, Japanese name, order, family etc. along with image of the type specimen. A similar type of web based information system for insect collections is developed at Indian Agricultural Research Institute, New Delhi (Jyoti *et al.*, 2002). It is known as Information System on National Pusa Insect Collection (ISNPIC), which is one of the biggest insect collections in Asia with more than half a million specimens comprising of approximately 17,000 identified species. Forestry images.org is another web-based image system which makes available about 4500 images of more than 800 insects, diseases, plants etc. (Douce *et al.*, 2001). This information system is supported by USDA Forest Service, Forest Health Technology Enterprise Team and Washington Office and the Forest Health Protection staff at United States.

In addition to literature search, scientists can use the web as a cost effective and efficient means of communication. Electronic mail, popularly known as e-mail, allows the users to exchange messages locally as well as worldwide. Scientists at remote areas or smaller institutions have a broader choice for direct communication to scientists of the highest reputation for advice or information than they had in past. A powerful aspect of e-mail is the option to send electronic files (text, spreadsheets and some images) as attachments. File Transfer Protocol (FTP) supplements e-mail attachments by quickly and cheaply transferring very large files e.g. databases and video files etc. Web based discussion groups enable the scientist simultaneously to discuss a subject. The Entomology Index of Internet Resources (VanDyk and Bjostad, 1999) lists more than 60 mailing lists likely to be of special interest to entomologists. The archives of Entomo-L, is the most used entomology mailing list.

The immense potential of web can also be used for conducting scientific meetings, seminars, symposia, conferences etc. without actually traveling and registration fees. It was well illustrated by the Fifth Internet Congress for Biomedical Sciences (IABS, 1998). During this meeting, which lasted 10 days, 1550 authors made 580 presentations and there were a plenary session, invited symposia and poster sessions.

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Retrieval of information from internet

The worldwide web is becoming an important component of information acquisition and exchange. There are a number of ways for retrieval of internet-based information.

Search engines

The use of search engines is the most common and easy ways to find information on the web. A search-engine allows the user to enter keywords related to a topic and retrieve information about web-sites containing those keywords. There are a number of search engines available on the web such as Google, Yahoo, Direct Hit, Northern Light, MetaCrawler, Excite, Magellan, Alta Vista, Ixquick Metasearch and Dogpile etc. According to Lawrence and Giles (1998), the best search engines (e.g. Yahoo, HotBot, AltaVista, Excite, Northern Light, Magellan etc.) index only one third of the total web pages. The best known search engine Yahoo, searches its category first rather than text of its web pages (Strassman, 2000). Generally, the search engines return thousands of links for a keyword, of which only a few are relevant to a user's search. In such cases search can be narrowed down by using the logical operators such as AND, OR, NEAR and NOT in advanced utilities. Apart from these general search engines subject guides/directories and specialty search engines are preferred because of their specificity to the subject. The most common example of subject guide is Entomology Index of Internet Resources. Among the specialty search engines, a few examples are as follows: Infomine – a resource guide for biological, agricultural and medicinal sciences, is a well organized web virtual library of IPM information (It is available at http://infomine.ucr.edu/search/bioagsearch.html). Several other search engines are available from IPM informatics website (http://ippc.orst.edu/ipminformatics) (Bajwa and Kogan, 1997).

Explore the deep web

The concept of 'deep' or 'invisible' web has emerged in recent times. This part of the web is not available for search by search engines i.e. we can say that this part is not visible to search engines. Thus, to access this type of invisible web one has to browse the database.

Join an e-mail discussion group or usenet newsgroup

A good web-based directory to assist in locating e-mail discussion groups and Usenet newsgroup is Listz, at http://www.listz.com/. Similary, the mailing lists of entomological interest can be found at the Entomology Index of Internet Resources. It can be going directly to a site and explore the web if you have the address of a site.

Internet and extension

The internet has emerged as an efficient, fast and accurate medium for transmission of information at a minimal cost. It can play an important role in providing timely information to farmers and helps in decision making. Dhawan *et al.* (2008b) has given an elaborative account of Decision Support Systems (DSSs) and their role in Integrated Pest Management. One such type of DSS for the management of cotton pests is operative in Punjab, India and can be accessed at http://www.pauipmcottondss.com (Dhawan *et al.*, 2008a). With the use of internet extension professionals and farmers can communicate directly with the experts. Many extension services offer 'Ask an Expert (AAE)' databases. User has access to this service 24 hours a day to contact an expert for answer to his queries. These services are better than using phone calls as the expert gets sufficient time to respond and he can complete the necessary research if needed before responding. Such type of 'Ask an Expert' service of Alberta Agriculture, Food and Rural Development of Canada is available at http://www1.agric.gov.ab.ca/staff/ate.nsf and of Virtual Plant and Pest Diagnostic Laboratory, Purdue University, USA is available at http://www.ppdl.purdue.edu/ppdl/Ask_Expert.html. In addition, many countries have developed electronic information systems. For example, cooperative extension database of Colorado State of USA can be accessed at http://www.colostate.edu/Depts/CoopExt/index.html., while that of Florida is available at http://edis.ifas.ufl.edu/.

Alternatively, farmers or extension professionals can send photograph of a plant problem to an expert to get proper advice for its solution. According to Gilman and Green (1998) these services are readily accepted and greatly appreciated by public. One example is the Distance Diagnostic Identification System (DDIS) (http://edis.ifas.ufl.edu/MENU_DDIS from the University of Florida, USA. In India, e-choupal initiative by a private sector company, Indian

Tobacco Corporation, is a good example of the role of internet in providing extension services to farmers. About 6500 e-choupals are operative in 39,000 villages of 9 states of India, which provide the rural people the global connectivity (Siva Kumar, 2007).

Web based models and decision support systems are becoming popular because little or no client software is required, thus, reducing software management and distribution costs (Power and Kaparthi, 1998). Decision support systems (DSS) play an important role in bridging the gap between science based technology and end-users who make day-to-day decisions. A DSS includes simple user-friendly front end to often complex models, knowledgebases, expert systems and database technologies (Coulson *et al.*, 1987; Jones, 1989). A number of resources are available for different pests. For example, the Southern Pine Beetle Internet Control Centre (SPBICC) of Virginia Polytechnic and State University (www.spbicc.vt.edu) (Salom *et al.*, 2001). It contains southern pine beetle growth predictive model besides interactive identification key for the identification of pest and other related information. CSIRO, Australia has developed software tools CLIMEX and DYMEX to develop population models of different insects which can be of great help for future forecast of the pest population to enable the grower to initiate timely control measures. By using these tools extension entomologists can develop population models of pests and they can contribute their modules to library of CLIMEX or DYMEX-Modelling Networks (http://www.ento.csiro.au/research/ pestmgmt/ IPMModellingNetwork/index.htm) for sharing with other users (Sutherst *et al.*, 2000). CLIMEX is available at http://www.ento. csiro.au /research/pestmgmt/climex/ climex.htm, while DYMEX at http://www.ento.csiro.au/research/pestmgmt/dymex/ dymexfr.htm.

Tiilikkala *et al.* (1999) predicted the population growth and flight activity of carrot fly, *Psila rosae* and cabbage root fly, *Delia brassicae* in Finland and displayed the predicted activity of these pests on AGRONET (http://www.mtt.fi/ks/ajankohtaista) for use by farmers and extension services. These forecasts were validated by means of pest monitoring data which were found to be in line with monitoring data. Thus, such type of forecasts can be of great help to farmers for decision making of timely control applications. FITO-INFO is an information system for plant protection which can be used to extension services. This system model contains information on organisms (taxonomy,

descriptions, images), pesticides (formulations, toxicology) and legislation (Dolnicar, *et al.*, 1999). It is accessible at http://bf.unilj.as/ag/fito. Internet has also proved fast, efficient and cost effective means of conducting electronic surveys for extension specialists (Bajwa and Kogan, 2000).

Internet and Teaching

The impact of internet on entomology teaching is the least realized/observed at this stage in a developing country like India. Internet has a great potential to become an effective teaching medium in the academic institutions. It can change the way instructors teach their students and students find and access information. Teachers can use the course websites and many institutions are in process of putting the course material on the web. Educators can post the information about their courses and syllabi of courses on the website like instructor's name, a brief introduction about course content, semester of the year etc. (Krafsur, 1998; NCSU, 1998; Coats, 1999; Courtney, 1999; Kondratieff, 1999). This type of information can be accessed by students at any time and helps to encourage potential students to enroll for a particular course. It is a simple first step for computer illiterate/reluctant faculty to try the web and realize its usefulness. Such type of web pages can be easily created on the word processing applications such as Microsoft Word as it offers the option to save documents in HTML format.

Additionally, the whole lecture notes for the course can be made available on the web for access by students (Meyer, 1998; Zenger, 1998; Grant, 1999; Higley, 1999; Pedigo, 1999; Stanley, 1999; TNAU, 2007). The lecture material can be in the form of HTML text and graphics, portable document format (PDF) files (Salmon and Roberts, 1997; Zenger, 1998; Fell, 1999; Salmon, 1999; Voshell, 1999) or Microsoft PowerPoint presentations (Zenger, 1998; Carroll and Mack, 1999). Audio (Carroll and Mack, 1999) and video clips (Brandenburg, 1999) can also be added to increase understandability of the subject. If desired, portions of course web pages can be password protected to limit access to the enrolled students (Meyer, 1998; Fell, 1999; Jurenka, 1999; York, 1999; TNAU, 2007). For those interested to study more about a topic, links to the websites may be provided (Salmon and Robertson, 1997; Zenger, 1998; Pfciffer, 1999; Radcliffe and Hutchison, 1999). Practice exams for a course can be posted on the site so that students can practice and assess their level (Salmon and Robertson, 1997; Meyer,

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1998). This helps the students to know about the topic in which they are weak and can review that topic.

In addition to the course notes, books can be uploaded on the web. One example of the online textbook is of IPM World Textbook by RedCliffe and Hutchison (1999). These online textbooks will become popular among the teaching and student community because printed books sooner or later become outdated and are expensive. The preliminary research indicates that the integration of the internet has a positive impact on learning when compared to traditional courses (Day *et al.*, 1998).

Thus, the immense potential of internet as a multi-way communication and information system can be well exploited to improve entomological research, extension and teaching. It is growing at an exponential rate and many new resources are being added to the web.

Table 1. Some outstanding entomological resources from different regions and perspectives.

Theme	Address*
Integrated Pest Management	
Compendium of IPM Definitions (CID)	http://www.ippc.orst.edu/IPMdefinitions/ home.html
CRC for Tropical Pest Management	http://www.ctpm.uq.edu.au/
Crop Protection Guide	http://www.agr.gov.sk.ca/docs/crops/ cropguide00.asp
CSIRO Stored Products and Structural Pests	http://www.ento.csiro.au/research/ storprod/storprod.html
Database of IPM Resources (DIR)	http://www.IPMnet.org/DIR/
FAO: Pesticide Management	http://www.fao.org/waicent/faoinfo/ agricult/agp/agpp/pesticide
Global Crop Pest Identification and Information Service in IPM	http://www.nysaes.cornell.edu/ent/ hortcrops
Global Plant Protection Information System	http://pppis.fao.org
Gypsy Moth Server	http://www.gypsymoth.ento.vt.edu/vagm/ index.html
Integrated Crop Management Newsletter (Iowa State Extension, USA)	http://www.exnet.iastate.edu/information/ newsletters.html
Integrated Crop Pest Management (Montana State University)	http://www.montana.edu/wwwey/ipm.htm
Integrated Pest Management (IPM) from Asia-Pacific Crop Protection Association	http://www.apcpa.org/imp.htm
Integrated Pest Management Alabama Program, Auburn University	http://www.aces.edu/department/ipm
Integrated Pest Management Information System	http://www.env.gov.bc.ca
Integrated Plant Protection Centre (from Oregon State University)	http://www.orst.edu:80/dept/ippc/ index.html
IPM Europe	http://www.nri.org/IPMEurope/ homepage.htm
IPMIST, Integrated Pest Management Information and Software Technology (China Agricultural University, Beijing)	http://www.ipmist.org/
IPMnet	http://www.ipmnet.org/
IPMnet News	http://www.ipm.ncsu.edu/cicp/ IPMnet_News/archives.html
IPMnet of China	http://www.ipmchina.en.net
Japan's Pesticide Database	http://chrom.tutms.tut.ac.jp/jinno/pesdata/ 00database.html
Malaysia Crop Technology	http://agrolink.moa.my/doa/english/ croptech/crop.html

Models of Plants, Pests and Beneficials Using Degree Days	http://www.ipm.ucdavis.edu/phenology/ models.html
Near Real Time Pest Alert Systems	http://ippc.orst.edu/pestalert/
Pest Management at the Crossroads	http://www.pmac.net/
Pest Management Research Information System (PRIS)	http://www.agnic.nal.usda.gov/agdb/ pris.html
Pest Management Resource Centre	http://www.pestmanagement.co.uk
Pesticide handling and storage tutorial	http://danpatch.ecn.purdue.edu/~epados/ farmstead/pest/src/main.htm
University of California Pest Management Guidelines	http://www.ipm.ucdavis.edu/
Biological Control	
Animal and Plant Health Inspection Service (APHIS)	http://aphis.usda.gov/
Biocontrol Site, USDA-ARS, Florida	http://www.usda.ufl.edu/biocontrol/ mitchell.com
Biological Control Institute, Auburn University	http://www.ag.auburn.edu/bci/
CSIRO European Laboratory	http://www.csiro.agropolis.fr/
EMBRAPA Biological Control Information System	http://www.sede.embrapa.br/english/ embrapa.htm
Entomopathogenic nematodes	http://www.bcc.orst.edu/~jiel/
A Guide to Natural Enemies in North America	http://www.nysaes.cornell.edu/ent/ Biocontrol
International Institute of Entomology	http://www.cabi.org/bioscience/
Mass Rearing of Beneficials	http://www.egrouups.com/list/entomology
Resource Centre for Rearing Beneficial Insects	http://www.mayhillpress.com/insects.html
Honey Bees	
APIS-Florida Extension Beekeeping Newsletter	http://www.ifas.ufl.edu/~mts/apis.htm
Bee Research Lab., ARS-USDA, Maryland	http://www.barc.usda.gov/psi/brl/ brl-page.html
Beekeeping	http://ourworld.compuserve.com/ homepages/beekeeping/
Extension Apiculturist, University of California	http://entomology.ucdavis.edu/faculty/ mussen.html
International Bee Research Association	http://www.cardiff.ac.uk/ibra/index.html
New Zealand Beekeeping	http://www.beekeeping.co.nz/
Ohio State University Bee Breeding Program	http://IRIS.biosci.ohio-state.edu/ honeybee/breeding
Raising Bees	http://www.farminfo.org/bees
Varrora jacobsoni and Honeybee viruses	http://www.res.bbsrc.ac.uk/entem/
Varrora mite treatment, Drone Method	http://www.xs4all.nl/~jtemp/ dronemethod.html
Taxonomy and Biosystematics	
Academy of Natural Sciences Insect Collection	http://www.acnatsci.org/biodiv/ index.html/entomology
Acridiidae of Florida	http://www.ifas.ufl.edu/~entweb/ghopper/ ghopper.html
Aquatic Insects	http://education.lanl.gov/resoruces/ ntep95/aquatic_insects/aquatic_insect_ id.html
Asilidae	http://www.geller-grimm.de/asilidae.htm
Australian National Insect Collection	http://www.ento.csiro.au/research/natres/ anic.htm
Beetles	http://www.source.at/beetles
Brachcera	http://www.res.agr.ca/brd/tachinid/ titlepag2.html
Bruchidae	http://fs1.bl.rhbnc.ac.uk/bruchid.htm
Buprestidae	http://users.iol.it./m.gigli.bup/
Butterflies and Moths	http://www.butterflies-moths.com
Butterflies of Netherlands	http://colo44202.student.wtwente.nl/ ~johan/
Butterflies of United States	http://www.npwrc.usgs.gov/resoruce/ distr/lipid/bflyusa/bflyusa.htm
Canadian National Insect, Arachnids and Nematodes' Collection	http://res.agr.ca/ecore/cnc/
Cerambycidae	http://members.tripod.com/hoskovec/ index.html
Chalcidoidea	http://res.agr.ca/ecore/apss/chalhome.htm
Chironomidae	http://www.ouc.bc.ca/fwsc/iwalker/ intpanis/index.html
Coleoptera	http://members.aol.com/lecdyatis3/ coleopteran.html
Coleoptera	http://www.coleoptera.org
Cornell University Insect Collection	http://henry.ento.cornell.edu/
Cynipoidea, Hymenoptera	http://www.algonet.se/~cynipoid/
Deutsches Entomologisches Institut-Eberswalde	http://www.dei-eberswalde.de/
Diptera	http://www.sel.barc.usda.gov/diptera/ diptera.html
Dragonflies	http://www.dragonflies.org
Ephemeroptera	http://www.famu.org/mayfly/index.html
Illinois Natural History Survey	http://www.inhs/uiuc.edu/ebd/collections/ insects.html
Integrated Taxonomy Information System	http://www.itis.usda.gov/itis/
Interactive Collections Availability List	http://www.bishop/hawaii.org/ical/
Interactive Katydid Key	http://viceroy.ceb.uconn.edu/interkey/ titlepg
International Soybean Arthropod Collection	http://insectweb.inhs.uiuc.edu/soy/isac/ index.html
Key to Praying Mantids of the World (Up to the level of genera)	http://info.ex.ac.uk/gjlramel/ mant-key.html
Leafhoppers	http://www.inhs.uiuc.edu/~dietrich/ leafhome.html

Lepidoptera of New Zealand	http://www.landcare.cri.nz/science/ biodiversity/projects/lepidoptera/
Membracidae of Malaysia	http://members.tripodasia.com.my/ yengwai/index.html
Moths of North America	http://www.furman.edu/~snyder/leplist
Moths of UK	http://www.geocities.com/rainforest/ canopy/6658
Nematocera	http://www.res.agr.ca/brd/tachinid/ titlepag1.html
New Zealand Arthropod Collection	http://www.insectweb.marc.landcare. cri.nz
North Carolina State University	http://www.cals.ncsu.edu/entomology/ museum/homepage.htm
Odonata	http://jcu.edu.au/dept/zoology/auxillary/ odonata.htm
Ohio State University	http://iris.biosci.ohio-state.edu/ inscoll.htm.
Oregon State Arthropod Collection	http://www.ent.orst.edu/osac/
Orthoptera	http://viceroy.eeb.uconn.edu/orthoptera
Pennsylvania State University's Frost Entomological Museum	http://viceroy.eeb.uconn.edu/interkey/ database.html
Phasmida	http://www.cas.psu.edu/docs/cashome/ frost.html
Queensland Museum, Australia	http://members.aol.com/fluffymark/ home.htm
Scarabaeidae	http://www.qmuseum.qld.gov.au/nature/ naturewelcome.html
Simuliidae	http://www.geocities.com/capacanaveral/ launchpad/9191/scarabaeidae.htm
Siphonaptera	http://gause.biology.ualberta.ca/craig.hp/ simuliid/simul.hp
Strepsiptera	http://www.zin.ru/animalia/siphonaptera/ index.html
Tachinidae	http://www.th-darmstadt.de/~pohl
Texas A & M University Insect Systematics Collections	http://www.res.agr.ca/brd/tachinid/ tacheng.html
University of Arkansas Arthropod Museum	http://www.ento.tamu.edu/research/ ressyst4.html
University of British Columbia Insect Collection	http://carvern.uark.edu/depts/entomolo/ museum/museum.html
University of Central Florida	http://www.insecta.com/
University of Colorado Insect Collection	http://pegasus.cc.ucf.edu/~biology/ bugcloset1.html
University of Georgia	http://www.colorado.edu/cumuseum/ research/entomology/entomology.html
University of Queensland	http://entomology.ent.uga.edu/collection
University of Wisconsin	http://www.uq.oz.au/entomology/ uqic.html
Western Australia Insect Reference Collection Database	http://www.entomology.wisc.edu/irc/ ircpage.html
	http://www.agric.wa.gov.au:7000/ento/ icdb/icdb1.idc
Toxicology	
Centre for Entomological Research and Insecticide Technology, University of New South Wales, Sydney	http://www.unsw.edu.au/clients/ unisearch/cerit/index.htm
Clemson University Pesticide Information Program	http://entweb.clemson.edu/pesticid/
Environmental Health	http://www.nichs.nih.gov/
EPA Pesticide Programs	http://www.epa.gov/pesticides/
EXTOXNET (Extension Toxicology Network	http://ace.orst.edu/info/extoxnet
Minnesotia Pesticide Impact Assessment Program	http://www.mes.umn.edu/~mpiap/
National Agriculture Pest Information System (NAPIS), USA	http://www.ace.orst.edu/info/nptn/
North Carolina Pesticide Impact Assessment Program	http://www.ipm.ncsu.edu/ncpiap/ homepage.htm
Pesticide Action Network	http://www.panna.org/panna/
Pesticide Broadcast, North Carolina Cooperative Extension Service Pesticide Newsletter	http://www.ipm.ncsu.edu/current-ipm/ broadcast.html
Pesticide Education Articles	http://www.iastate.edu/ipm/icm/indices/ pesticideeducation.html

Different resources shown here have been gleaned from The Entomology Index of Internet Resources (www.ent.iastate.edu/list/), an on-line database of entomological resources from Iowa State University.

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