Preprint LA-UR- 80-3166

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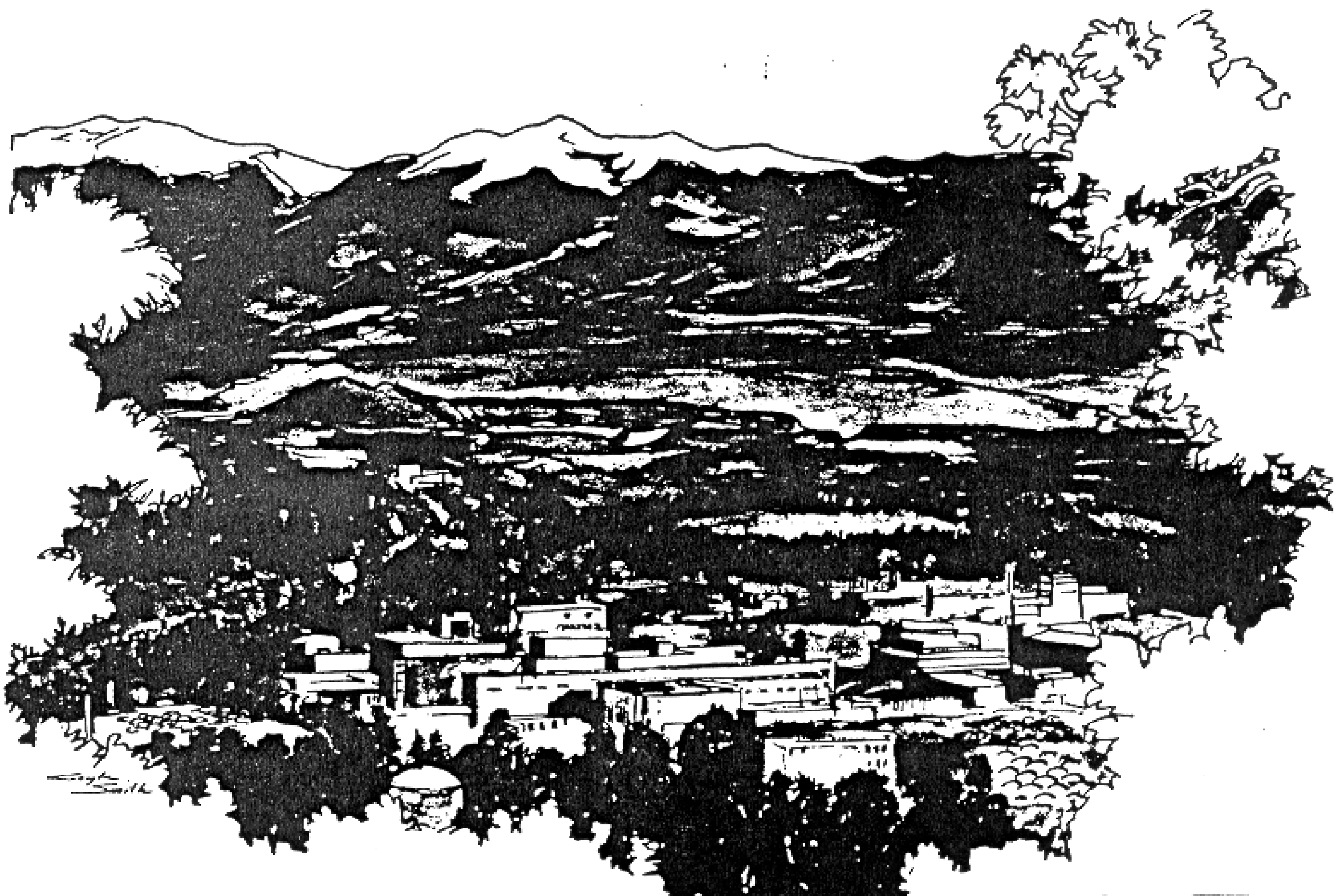
**Submitted to:** USAHA Meeting
Louisville, KY
November 3-7, 1980





LOS ALAMOS SCIENTIFIC LABORATORY

# PRESENT STATUS OF ELECTRONIC IDENTIFICATION

by

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## BACKGROUND

Electronic identification of animals was first seriously discussed at a USAHA meeting in Miami in 1972, when Henri Majeau of Boeing Aircraft Company discussed his design, John Hanton of Montana State discussed his concept and Dale Holm discussed a Los Alamos Scientific Laboratory (LASL) design. At subsequent meetings of the USAHA, reports have described the technical progress of the LASL design as particular problems were surmounted. By the end of 1977 implantable identification had been demonstrated. It was felt that most of the significant technical problems had been overcome and commercial manufacturers could be expected to enter into the development and testing. An announcement was made in the Commerce Business Daily in January 1978 to stimulate commercial interest in manufacturing equipment for a field test. As reported last year,[1] this resulted in a letter contract that was signed in September 1979 with Raytheon Service Company to produce equipment for the field test. A LASL system was installed at the USDA Jornada Experimental Range at Las Cruces, New Mexico in the fall of 1979 to demonstrate the capability of the LASL system in a field environment. Subsequent negotiations with Raytheon resulted in their withdrawal of their bid. With this development a re-evaluation of the program was made by the USDA/APHIS and LASL.

We at LASL and the APHIS were quite displeased with the long time taken in negotiations to obtain equipment, since this was the major roadblock in commencing with the field trials. Furthermore, the difficulties in consummating purchasing contracts were primarily in complying with procurement regulations and legal protection of both parties rather than technical problems. Therefore, a fallback plan was instituted to obtain field test equipment. A purchase contract was signed with Identronix in August 1980 to produce field test equipment and the first Identronix equipment is scheduled to be tested around the middle of November. LASL has also produced additional field test equipment and the first new LASL model interrogator/receiver and data logger with 20 transponders is currently undergoing tests at LASL.

## PRESENT STATE OF ELECTRONIC ID

There are some fundamental differences between the cattle industry in the United States and Europe. In Europe, there are no really large herds and there are very few beef herds. Dairy cattle serve the dual function of providing most of the local beef and milk. Whereas, in the United States, the dairy herd population is considerably smaller than the beef cattle population. Also, the interherd movement of American beef animals is quite large compared to dairies in both the US and Europe.

### Dairy Management Systems

Jeremy Landt of LASL visited a number of installations in Europe in the fall of 1980. He found the Europeans ahead of the United States in implementing electronic identification in dairies as part of computer data management systems. The European systems[2,3,4,5,6,7,8,9,10,11,12,13] have a range of a few cm in most cases. The identifiers are mounted on a neck collar and activated by a device on the protein concentrate feeders.

It appears that the only current research on identification systems is being done in Germany where improvements are being made in performance of inductively powered transponders. The data input to the computer often includes milk production, milk temperature and attention flags to alert the herdsman to antibiotics being given or to check the cow for estrus or pregnancy. In other cases the computer alerts the herdsman to a cow that is off her feed, or a high temperature in the milk claw. It appears that as many as 300,000 animals are now identified with these types of systems. While many comments are made in the sales literature about the benefits of using an automated system, we have not seen any cost/benefit analyses. We have seen technical details on only a few of the commercial European systems. However, the following seems to be true. Some of the identifiers have batteries for low-powered radio transmissions to a receiver that is in close proximity to the neck collar identifier when the animal is at the feed bin dispenser. In others, the identifiers do not have batteries, i.e., they are passive, and are energized by the induced field of an electrical coil.

Most systems are designed to identify from 255 to 1000 animals but we understand that some can be made to handle a much larger number of animals. Sales information was obtained on systems from a number of sources[9-13] and costs of the systems vary considerably with the computer options included. We understand that typically, the identifiers sell for about $55 each, interrogation site costs about $375 each, and the computer to handle up to 256 cows, sells for about $2000. Thus, a 100 animal herd with 16 stalls (8 milking parlors and 8 feedbins) for interrogation would cost about $13,500.

We have seen data on three American systems[14,15,16] with some similar operational characteristics to the European systems. The Electro Dynamics system[14] has milking parlor and concentrate feeding capabilities and we understand that their transponders sell for about $20 each, the computer system to handle about 256 cows and 16 stations sells for about $4100 and each interrogation station costs about $800.

The Pinpointer system[15] seems to be interfaced only with a feed dispenser. We have no cost information or performance information on this system.

The Identronix equipment that has been purchased for the field test is similar in concept to the LASL design.[1] It is an early production model designed for dairy herd management in the milking parlor. The costs of large scale production have not been realized. The external, identification only, transponders cost $150 each and the implantable temperature monitoring and identification transponders cost about $290 each. The interrogator/receiver costs $14,000 to service a single antenna. These are comparable to the costs of the LASL equivalents. Significant cost reductions are anticipated with integrated chip transponders and mass production. While this system is more expensive than those cited above, it was purchased because the design seems capable of being modified into a "National System."

We have also seen some information on an Australian concept being pursued by Tabtek. This system is fundamentally different from all others with which we are familiar. It uses an acoustical surface wave (SAW) type of transponder. The transponders are activated by a short pulse of radiowaves and this pulse is split into a number of parts. Each part is then delayed a different amount and then retransmitted back to the receiver as delayed pulses. We have analyzed their reports and have some reservations on how well it might work. These comments have been sent to the company but they have not responded. As far as we can tell, they have made some laboratory tests but do not have a fully operating system.

Feedlot Management Systems

There are two areas of feedlot management where we see potential benefits of a temperature monitoring and identification system. The early detection of shipping fever in the first month that an animal is in the feedlot could significantly reduce losses that sometimes approach 10-15% of a shipment. This could be done by automatic monitoring of animals going to feed and water and triggering an alarm when an abnormal temperature was registered or when the animal did not show up to eat or drink.

Mr. Linseth[17] believes that he can demonstrate a cost-benefit by successively weighing individual healthy animals soon after entering a feedlot and monitoring the weight gain curve. He then establishes criteria for culling animals with low feed to meat conversion efficiency. Currently, he needs to use people to separate animals so that only one animal is on the scale at a time and to identify the animal by reading an eartag. Electronic identification could eliminate the manual identification step and it is believed that an automatic method will be developed to separate the animals. Linseth indicated to us that by using a 20 ft long scale and obtaining multiple weights of each animal, as it crosses the scale, he can calculate with his microcomputer an accurate weight to about 1%. This is true regardless of the animal's speed.

National Systems

The USAHA and USDA/APHIS are primarily interested in identification as an aid to disease control rather than herd management. The National Livestock Electronic Identification Board (NLEIB) is interested in both the management aspects of livestock as well as disease control, so the specifications that they have approved include requirements for both applications. Most of the commercial systems now available address only the needs of dairy management and it is not clear if they can be modified to satisfy disease control requirements. The current models of transponders are not suitable for implanting because of consideration of electrical performance, size or encapsulation and therefore are not "permanent" identification. Only a few of the systems are capable of identifying a large number of animals or identifying moving animals at a distance of 10 ft.

The LASL system is capable of satisfying all of the NLEIB requirements for a "National System" with only small changes. We understand that some of the other systems might also be capable of satisfying these requirements. Some of the commercial systems that might be candidates for a National System are; Identronix,[16] Electro Dynamics,[14] and Tabtek.[17] The Identronix system is similar enough to the LASL design that we see no fundamental reason why it could not be designed to meet the NLEIB specifications. We have just learned about the Electro Dynamics system but do not have enough information to evaluate its potential. Their representative indicated that they could comply. We have plans to see a demonstration of their system in November 1980. We see little likelihood of any of the above systems being modified to satisfy the NLEIB specifications without some additional motivation.

The European systems being marketed in the US are a mixed blessing. On the positive side, is the amount of cost/benefit data that is being collected that can be applied to the dairy industry if a national identification system is developed. However, on the negative side, it will encourage the marketing of incompatible systems, that will not be suitable for a National Disease Control System because the identifiers are neither permanent nor have sufficient capability for identifying a very large number of animals.

FIELD TEST

As reported last year,[1] the letter contract negotiated with Raytheon Service Company authorized them to incur costs while the final contract was being negotiated. However, we were not able to reach final agreement and the contract was terminated in February 1980. We have a significant cost obligation to them that reduced the funds available for the purchase of equipment (the cost of the letter contract is under negotiation at this time). A reevaluation of the total program was made in March 1980 and we submitted our proposal to APHIS that suggested that they be prepared to carry the development through the production of production prototype equipment. This would include the production of fully integrated circuit transponders suitable for implantation without a surgical procedure. We also proposed that the development be programmed so that the USDA would carry the major financial load in demonstrating cost-effectiveness throughout the livestock industry (to stimulate widespread voluntary use) but would back out of any part of the program if the function was being performed by some other group.

At the September 1980 meeting with the APHIS personnel we were informed that because of the tight federal budget funds would be rather severely limited so that no more equipment could be procured and we would have to perform the experiments in this fiscal year with about 1-1/2 man years effort. This is quite a serious handicap because at this stage of the development, much effort is required for making ID equipment compatible with the sites and for debugging of the total system. These are normal problems inherent in the development of any new product.

With the funds available, we are purchasing two Identronix interrogator/receivers, one multiple antenna switch and controller, 50 neck chain transponders, and 115 implantable transponders with temperature measuring and identification. We have built two additional interrogator/receivers of LASL design and have assembled four LSI-11 minicomputer systems to log data and perform some on site data processing. We have obtained parts for 226 additional transponders, but the production yield is never 100%. So we expect about 150 usable t-ransponders.

Each identification system will include an interrogator/receiver unit, which powers up the identifying transponders and decodes the received signal. It will also have one or more antennas. If multiple antennas are used, a suitable antenna switch and controller will be installed.

The University of Illinois currently has two Identronix systems of an earlier design that they are using in an extension of their feeding experiments[19]. We decided that we would get the maximum return with the limited funds by placing an additional Identronix system there.

This will include an interrogator/receiver, all of the 115 implantable transponders, 12 antennae and the multiple antenna switch controller. The 115 transponders does not allow them to identify the complete herd. This is a serious drawback in determining reliability of interrogation.

The other Identronix system is scheduled to go in at University of Hawaii because they are developing a program for improving cattle performance in hot climates and can support the experiments. The APHIS committee has given the experiments with neckchains low priority because these units appear to promote a non-permanent identification system. We agree that it appears to promote non-permanent identification but we believe that important useful information can be obtained from neckchain systems. We ordered this type of transponder because the original experiments were to use calves that do not belong to the the experimenters and the calves were in their posession for only a few months. So they did not want to implant the transponders. An additional reason was that the cost of these transponders was about half that for the implantable type and we thought we could get more data for our money.

LASL has had one system operating at the Jornada Range in southern New Mexico for more than a year. It appears to be functioning quite reliably. However, we have had some trouble with the reliability of transponders and these few malfunctioning transponders have not been removed so we have not identified the difficulty. Our current plans are to implant the entire herd of 50 animals in this experimental range pasture. The remaining herd is scheduled for implantation during November and December 1980. A new LASL system is currently being tested at our laboratory and we are making plans to install it at the Meat Animal Research Center if we can formulate a satisfactory agreement on the experiments. The second LASL interrogator/receiver will serve as a spare. Both Identronix and LASL have had some difficulty in obtaining the necessary implantable transponders and it currently looks like the main delivery of these units will be in December.

Jornada Results

The first results of the experiments of the Jornada Range were presented in Australia.[20] These results indicated that reliable data can be obtained from an unattended system at a remote location, where power is generated on site and where weather conditions are extreme. In herd management it is important to know the weight gains as a function of time. These experiments showed that monitoring weights of specific animals on different days to determine weight gains of the herd gave less variation than averaging the weights of any group that came in on different days. This would lead to the conclusion that individual animal management has considerable advantage over group management. Although the weight scales are by the same manufacturer as those used by Linseth,[17] the accuracy for moving animals is considerably less, because Linseth has a longer scale and his own computer for averaging multiple weights.

Considerable difficulties were encountered in interfacing the LASL system with the electronic scale control minicomputer because the circuit diagrams and operating manuals were quite inadequate. The company was not very cooperative and has now gone out of business.

Because of the remote location of the test site, it was considerably more difficult to identify causes of problems and to resolve them. For example, on frequent occasions the system stayed activated for extended periods of time early in the morning when there was no animal on the scales. It was found that frost on the reflector of the infrared animal presence sensor was causing the trouble.

LASL Results

We at LASL still believe that temperature monitoring is an important aspect of a management identification system. But for it to be used effectively, work must be started to generate enthusiasm in testing its uses. While we recognize that this was not a primary concern of APHIS, it was still something that had to be addressed even in reduced effort.

Maatje and Rossing state[21] that estrus detection is indicated by a $\geq 0.3^{\circ}C$ change in milk temperature in 16 out of 19 cows. From these experiments, subdermal temperature monitoring does not look encouraging for estrus detection unless good data analysis codes are developed. Rossing also noted[22] that mastitis was fairly reliably detected by milk temperature prior to the detection by the herdsman or by reduction in milk yield.

Last year, we obtained subdermal temperature data from the proposed (behind the withers) implantation site. The results indicated there is a considerable amount of fluctuation in subdermal temperature. This variability was enough for us to question the usefulness of subdermal temperature in uncontrolled, outdoor environments and in many possible beef and dairy applications. It was important for us to determine whether this was a fact we had to live with or if there were ways to improve the quality of the data. Two possible ways to improve the data quality were considered; the development of computer routines for correcting subdermal temperature and the evaluation of other implant sites. Both approaches show promise of obtaining more meaningful information from subdermal temperature measurements.

Of the four subdermal sites we have tested, the withers area showed the greatest fluctuation in subdermal temperature. This was the area which was most directly exposed to both sunlight and rain. In comparison, abdominal and dewlap areas appear to provide more useful temperature readings (see Fig. 1).

When a fever was produced with IBR challenge (Fig. 2) subdermal temperatures appear to become less stable. However, abdominal subdermal temperature seems to reflect changes in an animal's true body temperature.

Once these more stable temperatures are obtained, it is still possible to correct them to obtain even more meaningful temperatures. We have been fairly successful in applying corrections for indoor subdermal temperatures and we are still working on several computer methods of improving the usefulness of the readings we obtained from these various sites in the outdoor environment.

Because of funding constraints, our efforts in this area of temperature monitoring have been limited. Problems exist in getting useful temperatures from electronic identification transponders at any subdermal sites. Disadvantages exist with all of the alternate subdermal sites we have tested in terms of ease of interrogating. However, a site may be found which is both practical from an interrogation standpoint and in terms of temperature. The results of these limited tests make us optimistic that with further work this could be a valuable inclusion in the entire concept.

FUTURE NEEDS

The future of electronic identification is certainly not clear at this time. The technical aspects have been demonstrated and there is a fairly high probability that it will be incorporated into non-agricultural uses such as, inventory control, license plates, and perhaps a type of credit card. However, this is a mixed blessing. If an integrated chip is developed for these systems that is not suitable for the agricultural needs, the original goals of this development will not have been realized.

The developmental work on electronic identification has been following a classical new product development program; recognition of a problem, proposed solution, proof of principle, design of preprototype equipment and its testing. This should be followed by the design of production equipment and its testing in a field environment. The amount of effort required to produce a viable end product goes up considerably from the preprototype testing to the final commercialization and distribution of a reliable final product. Certainly the development that has been funded by the USDA has reached a stage where it would be reasonable to expect private industry to pick up the ball and run with it. However, that does not seem to be the case at this time. If electronic identification is to become a reality for a National Disease Control System someone will have to take the necessary step of producing reliable transponders with fully integrated chip circuitry that have been adequately tested in a real livestock environment. The effort needs to be considerably greater than that which will be expended this year. Commercial manufacturers need to be brought into the program whether or not the government pays for the development.

There are still a few obstacles that could prove to be serious. Appropriate approvals have yet to be obtained from the FDA, OSAHA and FCC for the establishment of the National System. While we do not think that there is a high probability at this time, it is conceivable that new and more stringent standards of microwave exposures could be imposed that would prohibit the effective use of the system that we have designed. We expect a reduction in the acceptable microwave exposure level, but we do not expect it to be reduced to a level that would make the system impractical. We believe that the temperature measuring capabilities should be included because of its potential for disease detection, although we recognize it may not be satisfactory for reliable estrus detection. A considerable amount of work also needs to be done, after the development of the National System is assured, to the application of the system to other species. It will probably be necessary to establish a national records system that will form the data base for a National Disease Control System.

A commitment by both private industry and the government is necessary if a modern, highly-computerized National Disease Control System is to become a reality. We wish to also stress that without the active support of the livestock industry, electronic identification could be just one more bit of bureaucracy imposed upon the industry with limited benefits. However, if there is an active effort to investigate and promote cost-effective and voluntary use of electronic identification, a system of mutual advantage could be developed with benefit to the industry and the consuming public, and it will improve efficiency of regulatory agencies. For this reason, the NLEIB performs an important role by providing the platform for communicating the concerns of potential users and regulators. However, if all of these needs are to be satisfied, there must be commercial equipment available that is suitable for a National System.

We believe that a strong leadership position by the APHIS is also needed at this time. This leadership position needs to be supported with enough funds to ensure the development of a commercial product suitable for a National Disease Control System. This leadership should include the commitment to carry the development of electronic identification through to the commercialization of hardware and to develop the necessary data base management system software to use the data when it is available for disease control. If that leadership is not present, there is a high probability that multiple and incompatible electronic identification methods will be developed for a number of specialized applications but not for disease control.

We are at the stage in electronic identification where we have gone through the preliminaries, we have survived the various tests and we believe that the system we have developed is the best in the world. But it does not look like we will be able to participate in the final test.

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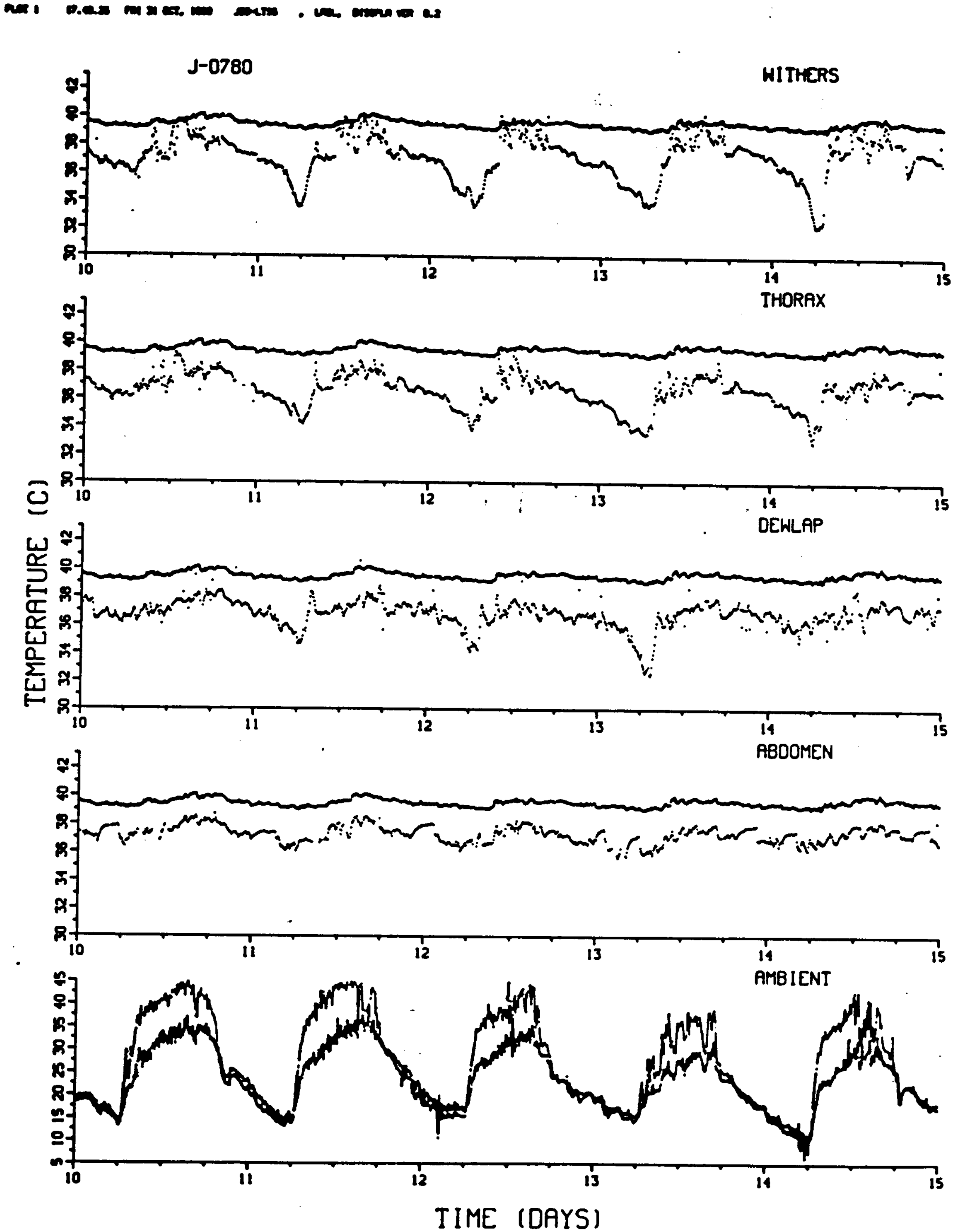
FIGURE CAPTIONS

Fig. 1 Temperature patterns of a single animal in an uncontrolled outdoor environment from days 10-15. The first four graphs show comparisons of tympanic membrane temperature (top curves) with the temperatures of subdermal withers, thorax, dewlap and abdominal (bottom curves) and the bottom graph shows that there is a greater fluctuation between the black globe (top curve) and ambient (bottom curve) temperatures.

Fig. 2 Shows similar temperature patterns as in Fig. 1 from day 18 to 25. A fever started on day 20.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WITHERS
THORAX
DEWLAP
ABDOMEN
AMBIENT
TEMPERATURE (C)
TIME (DAYS)

Fig. 1

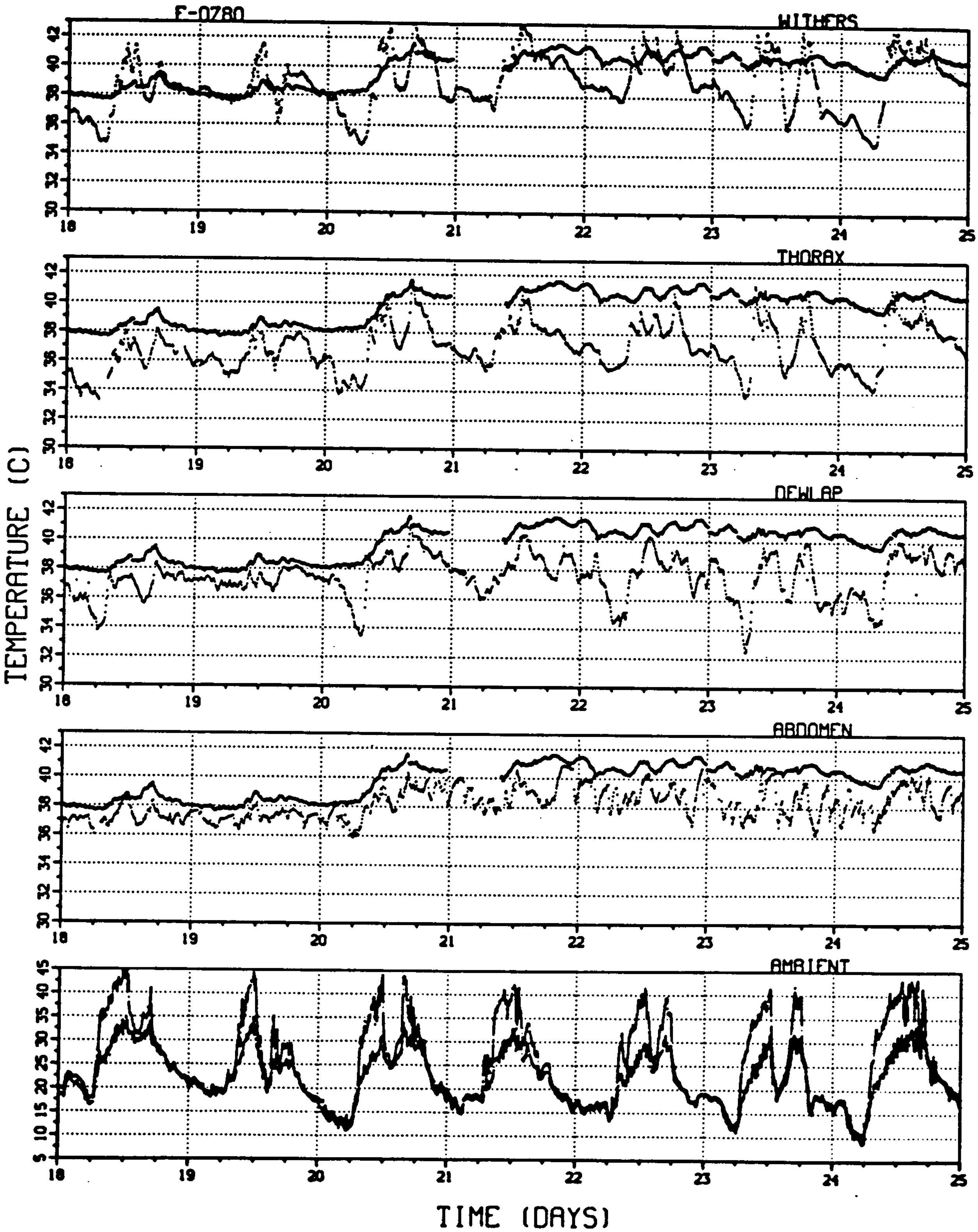
F-0780
WITHERS
THORAX
DEWLAP
ABDOMEN
AMBIENT
TEMPERATURE (C)
30 32 34 36 38 40 42
5 10 15 20 25 30 35 40 45
18 19 20 21 22 23 24 25
TIME (DAYS)

Fig. 2