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Arizona's Efforts to Reduce Lead Exposure in California Condors

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Abstract.—Exposure to lead is one factor affecting the success of the California condor (*Gymnogyps californianus*) reintroduction program in Arizona. There have been 176 documented cases of lead exposure and 66 chelation treatments administered since 1999. Six condor deaths have been attributed by necropsy to lead poisoning. To address this, the Arizona Game and Fish Department (AGFD) and its partners are working to reduce lead exposure due to spent lead ammunition found in animal carcasses and gut piles. We have focused on public education, scientific research, and voluntary use of non-lead ammunition. In 2003, 205 Arizona hunters were interviewed by phone. Only 23% of the hunters were aware that lead poisoning was a problem faced by condors, but 83–97% were willing to take some action to help condors if credible lead exposure data were made available. Focus groups then rated condor conservation and lead reduction messages. As a result, condor lead data and conservation messages have been provided to the public since 2003. The AGFD and The Peregrine Fund are also funding research to investigate the link between lead ammunition and condor lead exposure. Preliminary results confirm lead from ammunition is a major source of lead exposure in condors. Other efforts include the formation of a voluntary lead reduction coalition consisting of sportsmen's groups and government agencies. The AGFD also funded a pilot program for the fall 2005 hunting season, providing free non-lead ammunition to deer hunters within the condor range. We hope the combination of these efforts will decrease the number of condor lead exposures in the future.

For several years, biologists have linked lead poisoning in wild California Condors (*Gymnogyps californianus*) to the ingestion of spent lead ammunition in animal carcasses (Janssen et al.1986; Weimeyer et al.1988; Snyder and Snyder 1989, 2000; Pattee et al.1990). More recently, lead from spent ammunition has been linked to lead exposure and lead

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toxicity in reintroduced, captive-reared condors in both California and Arizona (Meretsky et al. 2000, Snyder and Snyder 2000, Fry and Maurer 2003, Cade et al. 2004). In Arizona, significant efforts to verify the association between spent lead ammunition and condor lead exposure, as well as to educate the public and engage hunters in voluntary lead reduction efforts, began in 2003.

The first release of California Condors in Arizona occurred on 12 December 1996. As of 30 September 2005, 84 condors have been released in northern Arizona. Fifty-seven condors, including four wild-hatched chicks, inhabit northern Arizona and southern Utah. Although the project is making progress, 29 condors have died since 1996. The leading cause of death is lead toxicity, with six confirmed cases. The first major condor lead exposure event in Arizona occurred in June 2000, resulting in the death of three condors (Woods et al. this volume). Since that time extensive trapping and testing of condors for lead exposure has occurred in Arizona. Condor blood tests have identified 176 cases of lead levels indicative of lead exposure, while in sixty-six cases, condors required chelation therapy to treat dangerously high lead levels. Further, ingested lead pellets or bullet fragments have been recovered from 14 individual condors (Parish et al. this volume). Without the intervention of chelation therapy and other measures, additional condors would have succumbed to lead poisoning.

As elsewhere in their current range, the condors are supplied with a clean, lead-free supplemental food source of calf carcasses at the release site in Arizona. As condors disperse from the release site, they forage on carcasses of wild animals, such as mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and coyotes (*Canis lantrans*). Since 2000, the highest frequency of lead exposure in condors has been associated with increased condor movements away from the release site, and the consumption of non-proffered carcasses potentially containing lead (Hunt et al. this volume). Moreover, the highest numbers of lead exposure events have repeatedly occurred during the fall hunting season (Hunt et al. this volume). Although field biologists have managed to reduce the number of condor deaths due to lead toxicity by pursuing a rigorous monitoring and treatment protocol (Parish et al. this volume), these efforts are highly invasive, labor intensive, and costly. Moreover, the long-term sub-lethal effects of lead exposure in condors are unknown (but see Snyder this volume). Thus, it is unlikely that condors in Arizona will achieve a self-sustaining population at the current lead exposure rates.

While research into the prevalence and effects of lead on condors (e.g., Fry and Maurer 2003, Fry 2004, Church 2005) and lead reduction efforts (see www.projectgutpile.org/) have also occurred in California, efforts in Arizona have focused on voluntary measures to reduce the amount of lead available to condors in the wild. This is due to a consensus among project

cooperators that voluntary measures are the best course of action to take in Arizona. Further, unlike releases in California, condors in Arizona are released under the 10(j) rule of the Endangered Species Act, which limits laws altering current land management practices (U.S. Fish and Wildlife Service [USFWS] 1996).

Lead Reduction Efforts

Surveys and focus groups.—In May 2003, the lead mitigation subcommittee of the California Condor Recovery Team compiled a report on condor-lead issues (Redig et al. 2003). As part of the effort to reduce lead exposure in condors, USFWS contracted the Wildlife Management Institute (WMI) to determine hunter knowledge of and attitudes towards lead poisoning in condors. Responsive Management and D. J. Case and Associates (D. J. Case) were contracted by WMI to carry this out.

During the fall of 2003, Responsive Management conducted phone surveys of 205 Arizona hunters (Responsive Management 2003). Among other questions, hunters were asked if they were aware that lead poisoning was a problem faced by condors; if they were aware of any educational efforts to try to reduce lead poisoning in condors; and what actions they would be willing to take to help reduce lead exposure in condors (Responsive Management 2003). Key findings from the surveys included that only 23% of Arizona hunters were aware that lead poisoning was a problem faced by California Condors, and only 9% were aware of any educational efforts to reduce condor deaths from lead poisoning (Responsive Management 2003). However, 83–97% stated they would be somewhat to very willing to take some action to help condors (Responsive Management 2003). The actions hunters would be willing to take included: removing all carcasses from the field; burying or hiding all gut piles; removing bullets and surrounding affected flesh; and using non-lead ammunition (Responsive Management 2003). These data established a baseline to measure subsequent changes in hunter knowledge and opinions.

D. J. Case incorporated the data from these phone surveys with information from interviews of condor professionals and literature searches to develop condor conservation and lead reduction test messages. Test messages were discussed and rated on a scale of 1–5 during three focus group meetings of Arizona hunters and ranchers held in December 2003 (D. J. Case and Associates 2005). The best scoring (1.89) communication message from the focus groups was:

> Hunters and ranchers have a long history of caring for the land and conserving all kinds of wildlife. They can continue this tradition and help prevent lead poisoning in California condors by taking

> one or more of the following actions in condor range: use non-lead ammunition; retrieve all animal carcasses; hide carcasses or gut piles to make them inaccessible to condors; and/or remove bullet and affected flesh from animal carcasses left in the field. (D. J. Case and Associates 2005)

Focus groups also revealed that hunters and ranchers were not convinced that spent lead ammunition was a major cause of condor lead poisoning (D. J. Case and Associates 2005). They requested credible data linking lead ammunition to condor lead poisoning (D. J. Case and Associates 2005). They also expressed a greater willingness to help condors if asked by a credible source (D. J. Case and Associates 2005). In Arizona, hunters and ranchers considered sportsmen's groups and the state wildlife agency to be the most credible sources (D. J. Case and Associates 2005).

Focus group results were then utilized to develop a communication strategy. The strategy included actions such as increased education, communication and cooperation between condor project cooperators and the hunting community, continued condor lead exposure research, and the implementation of a non-lead ammunition program (D. J. Case and Associates 2005).

Education and communication.—Data obtained from the phone surveys and focus groups were utilized to create an education and communication strategy (D. J. Case and Associates 2005) to gain support for voluntary lead reduction efforts in Arizona's condor range. In 2003, the AGFD began hunter education and communication efforts and have expanded these efforts each subsequent year. Each year from 2003–2005, condor lead exposure data, accompanied by a request for voluntary lead reduction actions were mailed to 2,000–7,500 hunters drawn for hunts within the condor range in northern Arizona (Fig. 1). In addition, a full page in the Arizona hunting regulations has been devoted to the condor conservation and lead reduction message since 2003.

The AGFD encouraged local sportsmen's groups to join a Condor Coalition consisting of sportsmen's groups and government agencies supporting voluntary efforts to reduce the amount of lead available to condors. As of 31 December 2005, Condor Coalition members included the Arizona Antelope Foundation, Arizona Deer Association, Arizona Desert Bighorn Sheep Society, AGFD, Boone & Crockett Club, California Chapter of the Foundation of North American Wild Sheep, California Deer Hunters Association, California Department of Fish and Game, International Hunter Education Association, National Shooting Sports Foundation, North American Grouse Partnership, Sporting Arms and Ammunition Manufacturers' Institute, USFWS, and Wildlife Management Institute. Coalition members support voluntary lead reduction efforts within the condor range, as well as fund condor conservation and lead reduction

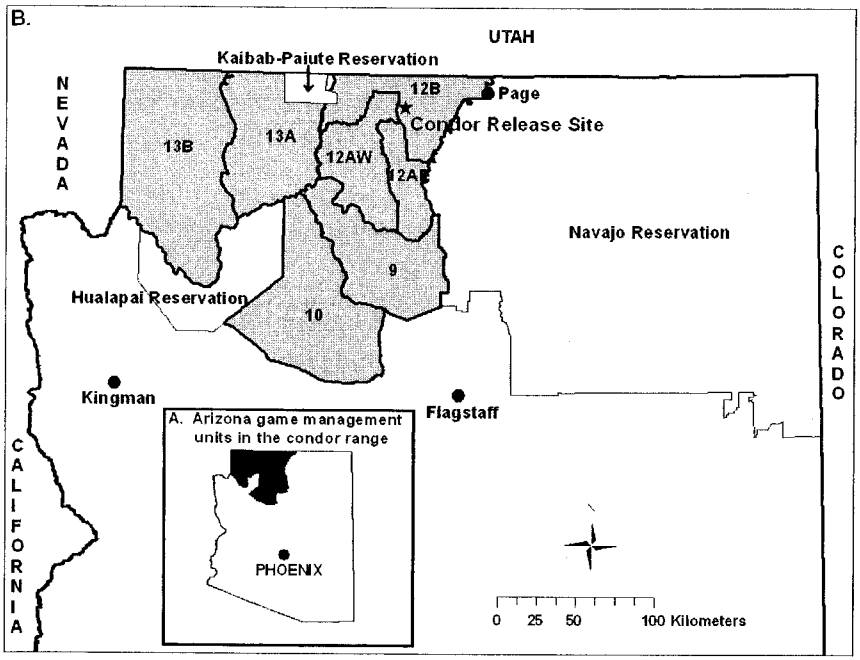

FIG. 1. Game Management Units (B) within the condor range in Arizona (A). Hunters drawn for rifle deer and big horn sheep hunts in Units 12AE, 12AW, and 12B qualified for the 2005 free non-lead ammunition program. Hunters drawn for big game rifle hunts in Units 9, 10, 13A, and 13B were mailed letters asking them to take voluntarily lead reduction actions.

educational efforts. The Coalition is currently funding an educational web page (see www.condorinfo.org/). Personnel from cooperating agencies of the Arizona condor project, including AGFD, The Peregrine Fund (TPF), National Park Service, USFWS, U.S. Forest Service, and Bureau of Land Management attended "one-voice" condor training on 5 August 2005. Project cooperators were trained to communicate a consistent and effective message regarding voluntary lead reduction efforts in the condor range. Personnel also continued to disseminate the condor lead exposure reduction message within their agencies and to the public. Representatives from Arizona sportsmen's groups also attended "one-voice" condor training on 6 August 2005 in order to disseminate accurate and consistent information to their members.

The general public has received the condor conservation and lead reduction message through educational presentations, wildlife fair displays, the Internet, and media outlets. Forty to seventy condor educational programs

have been presented each year between 2003 and 2005. AGFD's web page (www.azgfd.gov/) first carried the condor lead reduction message in 2003, and has expanded and updated this site each year to incorporate ongoing research and new information on condors and lead. Media coverage has included magazine and newspaper articles in local publications, as well as a condor segment on AGFD's "Wildlife Views" television program.

Lead research.—Arizona hunters and ranchers indicated they needed more data linking lead ammunition to condor lead poisonings to increase their support for voluntary lead reduction efforts (D. J. Case and Associates 2005). The AGFD and TPF responded by conducting and funding five research projects related to condor lead exposure and lead ammunition. Firstly, TPF condor project biologists recorded condor lead exposure and lead ammunition ingestion by condors starting in 1999 and have summarized the data through June 2005 (Parish et al. this volume). Secondly, lead toxicity mortality rates were recorded by TPF and summarized through January 2005 (Woods et al. this volume). Data from these two studies verify that lead exposure is a critical management issue in Arizona. Starting in 2004, condor lead exposure, lead ingestion, and lead toxicity data have been reported to hunters in the annual AGFD hunting regulations and reported to the public through educational programs.

Thirdly, since 2003, AGFD has purchased 21 GPS satellite transmitters to track condor movements. Transmitters were mounted on the patagia of individual condors and TPF used data from these transmitters along with data from conventional VHF transmitters to compare condor movements between July 2001 and June 2005 in relation to lead exposure rates (Hunt et al. this volume). An association between high lead exposure rates and increased use of the Kaibab Plateau in northern Arizona during deer hunting season was confirmed (Hunt et al. this volume). Starting in 2005, data from this study have been shared with hunters and the public.

Fourthly, TPF conducted research from 2002 to 2004 to determine the extent of lead bullet fragmentation in rifle-killed deer (Hunt et al. 2006). This study demonstrated that standard lead bullets typically fragment into hundreds of pieces before exiting a target such as a deer, and that these fragments remain in the deer carcasses as well as the gut piles. The study also confirmed that the fragmentation rate of pure copper bullets is minimal compared to that of lead bullets (Hunt et al. 2006).

The fifth study is an ongoing lead isotope study funded by the AGFD and conducted by the University of Arizona, Tucson, using biological samples provided by TPF condor biologists. This study aims to conclusively determine the pathway for lead exposure in condors. Lead isotope ratios of condor blood and lead removed from condor digestive tracts are being compared to lead isotope ratios of lead retrieved from carcasses on which condors feed, lead ammunition, and other possible lead sources (J. Chesley

et al. 2006). Preliminary results have established a direct match between lead ammunition and lead found in condor blood and digestive tracts (J. Chesley pers. comm.). As they become available, data from this study are incorporated into the communication strategy and shared with the public.

Non-lead ammunition program.—The AGFD, using money from the Heritage Fund (i.e., Arizona state lottery revenue), administered a free non-lead ammunition program for the fall 2005 hunting season. AGFD partnered with Cabela's, Sportsman's Warehouse, and Federal Ammunition to offer two free boxes of non-lead ammunition (Table 1) to 2,393 deer and bighorn sheep rifle hunters drawn for hunts in Game Management Units 12A and 12B (areas located within the core condor foraging range) (Fig. 1). Coupons to obtain the free ammunition accompanied a letter outlining condor lead poisoning issues and asking for hunters' help in reducing the amount of lead available to condors. Coupons were mailed at the beginning of August 2005. The 2005 rifle-hunting season began in late October and continued through December. Coupons were redeemable through 15 November 2005. Sixty-five percent (n = 1,551) of eligible hunters participated in the program by redeeming their coupon for non-lead ammunition.

To evaluate the success of this program, AGFD worked with D. J. Case to develop two post-hunt surveys, one for non-lead ammunition program participants and one for non-participants. Surveys were mailed in November to all 2,393 eligible hunters. A total of 1,105 surveys (46%), including 943 participant (61%) and 162 non-participant (19%) surveys

Table 1. Non-lead ammunition offered during Arizona Game and Fish Department's 2005 free non-lead ammunition program. Sixty-five percent (1,551) of the 2,393 eligible hunters drawn for big game rifle hunts within the primary condor range of Arizona redeemed a coupon to receive two free boxes of their choice of this rifle ammunition. One thousand six hundred fifty-eight coupons were redeemed (107 participants redeemed 2 coupons). The ammunition brand was Federal Premium Vital Shok, loaded with Barnes 100% copper Triple Shock X-bullets.

Caliber	Bullet grain weight	Number of coupons redeemed
.25-06 Remington	100	44
.270 Winchester	130	343
.270 Winchester Short Magnum	130	21
7MM Winchester Short Magnum	160	14
7MM Remington Magnum	160	291
.308 Winchester	150	130
.30-06 Springfield	180	534
.300 Winchester Short Magnum	180	47
.300 Winchester Magnum	180	182
.338 Winchester Magnum	225	52

were completed and returned by 15 December 2005. D.J. Case will submit a final report to AGFD in the spring of 2006.

Preliminary findings suggest the main reasons why hunters participated in the non-lead ammunition program were: they were asked to participate by AGFD (95%); they wanted to help condors (92%); and the ammunition was free (87%). Survey results indicate that 81% of all participants used the free non-lead ammunition during their hunts. Ninety-three percent of the respondents who harvested a deer ($n = 380$) said the non-lead ammunition performed the same as, or better than, lead ammunition. In addition, 97% of the respondents who tested the non-lead ammunition ($n = 796$) stated its accuracy was average to excellent. Eighty-nine percent of the respondents said they would use non-lead ammunition again if it was provided for free, and 56% indicated that they would purchase it on their own in the future. Lastly, 72% of the respondents said they would recommend non-lead ammunition to other hunters.

Non-participant survey results indicated several reasons why hunters did not participate in the free non-lead ammunition program. Twenty-five percent of respondents listed their main reason as the program failing to offer their desired caliber of non-lead ammunition, and 15% indicated that the program was too complicated or a hassle. Forty-three percent stated their reason for non-participation as "other." "Other" reasons included: coupon was lost ($n = 18$); forgot to participate ($n = 9$); already using non-lead ammunition ($n = 6$); did not hunt ($n = 3$); and do not support this program ($n = 3$). Non-participants suggested that offering more calibers of non-lead ammunition (64%) and providing more information on condor lead poisoning (38%) would have encouraged more hunters to participate in the free non-lead ammunition program.

Concurrent with our lead reduction efforts, TPF continued to track condor movements and foraging locations, as well as to collect lead exposure, treatment, and poisoning data in 2005 through periodic sampling of trapped birds consistent with approximate timing and methods used in previous years. The observed results from 2005 indicated a 40% reduction in samples indicating exposure from the previous year (Parish unpubl. data). Preliminary data also revealed a 29% decrease in the proportion of birds exposed from 2004 to 2005 (Parish unpubl. data). This appears to represent the first annual decrease in the proportion of tested condors with levels indicating exposure to lead since 2002, when birds first started using the Kaibab Plateau during the fall hunting season (Parish et al. this volume). Although these changes in indicated exposure may in part relate to differences in condor movement patterns between 2004 and 2005 (Hunt et. al. this volume), the reasonable assumption is that fewer lead-laden carcasses on the Kaibab Plateau in 2005 played a significant role in the decrease of condor lead exposures.

Discussion

Although studies have identified lead from spent ammunition as a source of lead poisoning in condors (see Janssen et al.1986; Weimeyer et al. 1988; Snyder and Snyder 1989, 2000; Pattee et al.1990; Fry and Maurer 2003; Cade et al. 2004), phone surveys and focus groups revealed that the majority of hunters in Arizona were either unaware that lead was a problem for condors, or were not convinced that the use of lead ammunition contributed to lead toxicity in condors (Responsive Management 2003, D. J. Case and Associates 2005). Since hunter cooperation is crucial to reducing the amount of lead available to condors, we are providing hunters with the requested evidence linking condor lead poisoning to spent lead ammunition. In addition, efforts are being made to communicate the lead reduction message in the most effective manner by focusing on the proud tradition of hunter wildlife conservation. We believe this combined approach has resulted in a greater awareness of condor-lead issues among hunters in Arizona. It has also resulted in increased support from sportsmen's groups. We acknowledge that changing human behavior can be a cumbersome process, but we believe that by continuing to expand our efforts, we could see a significant effect of such changes on condor lead exposure rates, thus providing the opportunity for a self-sustaining condor population in Arizona. The apparent sizable reduction in condor lead exposures experienced in 2005 is hopefully the first step towards this goal.

It is important to note that while the current free non-lead ammunition program is focusing on reducing the use of lead bullets in condor range, reducing the use of lead shot in condor range is also important. In Arizona, lead shot has been removed from the digestive tract of condors as frequently as lead bullet fragments (Parish et al. this volume). Condor ingestion of lead bullet fragments has been associated with the fall hunting season (Hunt et al. this volume), while condor ingestion of lead shot has been less predictable, and is not associated with a well-defined hunting season. Therefore, a free non-lead shot program would be logistically complex and probably much less effective than a free non-lead bullet program. Future lead reduction efforts will include increased attempts to reduce the use of lead shot within the condor range. We do acknowledge, however, that these efforts may be less productive than lead bullet reduction efforts. We still remain hopeful that the voluntary use of non-lead shot will increase due to our communication efforts.

A significant factor in the success of voluntary lead reduction efforts is the availability and affordability of non-lead ammunition. Although non-lead shotgun pellets are commonly available, only a few bullet manufacturers offer non-lead rifle ammunition alternatives (Table 2), with a selection that is far less complete than that of lead ammunition. And although the

Table 2. A sample of ammunition manufacturers that offered non-lead ammunition in 2005. Non-lead rifle ammunition is loaded with 100% copper Barnes X, Barnes XLC, Barnes Triple Shock X, and Barnes Solid bullets. Non-lead shot is composed of steel, tungsten, and bismuth. For a more complete list, including available calibers and shot sizes, go to the California condor web page at www.azgfd.gov/condor.

Non-lead rifle ammunition manufacturers	Non-lead shot-gun ammunition manufacturers
Black Hills Gold	Bismuth Cartridge
Conley Precision Cartridge	Federal Premium Ultra Shok
Federal Premium Vital Shok	Hevi-shot
PMC Gold Line	Kent Cartridge
PMP Super Rifle Ammunition	Remington Premier
Safari Arms Ammunition	Sellier and Bellot
Superior Ammunition	Winchester
Weatherby Premium	Wolf Ammunition

recent increase in availability of non-lead ammunition gives cause for optimism, we encourage ammunition manufacturers to further expand the production of non-lead alternatives. We also request that ammunition retailers offer more non-lead ammunition for their customers. Our free non-lead ammunition program will not continue indefinitely, so it is crucial that sportsmen in the condors' range are able to procure a wide variety of non-lead ammunition at reasonable prices.

Future work to reduce condor lead exposure will include expanding education and communication efforts by increasing the number of educational presentations, while specifically targeting hunters and sportsmen. Future education and communication efforts will attempt to include the state of Utah, the Navajo Nation, the Kaibab-Paiute Reservation, as well as other American Indian Reservations within the condor range. We also plan to incorporate strategic use of the media. Attempts will be made to place the condor conservation and voluntary lead reduction message in popular literature as well as in sportsmen and hunter publications. Messages will focus on the conservation history of hunters and commend those hunters and sportsmen's groups who support lead reduction efforts within the condor range. The success of these efforts will therefore be dependent upon the cooperation of media organizations.

Future efforts to expand the Condor Coalition will focus on recruiting influential local and national sportsmen's groups. Since hunters consider sportsmen's groups the most credible source for information, the use of Coalition members' names in hunter correspondence will be a valuable communication tool. Coalition members will also be asked to contribute to educational efforts and possibly assist in funding the voluntary lead reduction program. Relevant lead research will also continue. Results

from the University of Arizona's lead isotope study will be published and shared with the public, as will results from the free non-lead ammunition program. Future lead research will be considered and could include lead isotope studies of feathers to determine lead exposure levels and sources (Fry 2004).

It is essential to assess whether voluntary lead reduction efforts in Arizona are effective in reducing the amount of lead available to condors. To accomplish this, we will combine sustained condor lead exposure monitoring with hunter surveys. TPF will continue condor lead exposure testing to determine if lead exposure rates decrease. Contingent upon AGFD securing funding, a follow-up survey is proposed for 2007 (D. J. Case and Associates 2005) to determine if education and communication efforts have resulted in an increased awareness of condor issues and a decreased use of lead ammunition in the condor range.

Voluntary efforts to reduce lead in the condor range have been criticized as likely to be ineffectual in reducing the threat of lead to condors and hence the long-term success of condor populations. However, our results to date suggest that the voluntary program of non-lead ammunition use by hunters within the condor range of Arizona has the potential of being highly effective. We believe our efforts demonstrate the merits of communicating and collaborating with sportsmen on this issue. Since the opinions of surveyed hunters on the efficacy of non-lead ammunition have been consistent with widespread reports of its excellent ballistic qualities, we expect the use of non-lead ammunition to increase as it becomes more available and affordable, and hence benefit condor recovery efforts.

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